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Cars 2025: Vol. 1

A disruptive new era of the Automotive Age

Equity Research

Technology accelerating a rapid shift in the future of mobility

Paradigm shift over next decade

The auto industry's need to embrace technological change is more urgent now than ever before.

Innovations are accelerating, opening up opportunities – and challenges – for automakers: Cars that lack steering wheels, brake when they sense a person or object, emit only water when on the move, or use advanced materials like carbon fiber reinforced polymer – these are just some of the innovations that will be commonplace by 2025.

We will explore all these developments and their implications in this new series of reports, Cars 2025. In this inaugural report, we identify four key themes we expect to define the car of the future (Green, Safe, Convenient and Affordable) and seven megatrends that we believe will transform the industry over the next decade. Our intent is to create an outline for examining the future of mobility in upcoming reports.

Seven megatrends

1. Endless powertrain advancement: Electrified vehicles will become 25% of global car sales by 2025.

2. Autos on a severe diet: A 50kg drop in vehicle weight cuts CO2 emission volume by at least 1g per km. New materials to reduce car weights.

3. Autonomous driving on horizon: Google wants to realize Level 4 automation by 2017. Autonomous driving could change society.

4. Power shift to mega suppliers: Meeting CO2 regulations will cost automakers US$2,500 per vehicle. We expect the presence of mega suppliers to expand.

5. New entrants afoot: The appearance of autonomous driving and EV is removing auto business entry barriers.

6. Connected cars and shared mobility: Networked cars changing business models for industries from insurers to rental fleets.

7. Shift to emerging markets: Motorization in emerging markets continues unabated. By 2025, we expect China to have 35 mn vehicles and India 7.4 mn vehicles.

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Overview: Why must cars evolve?

With close to 100mn cars sold every year, the auto industry is a large, established business with roots stretching back to the late 1800s. However, despite all the history in the rear-view mirror, mapping out the road ahead remains a challenge. What will the typical car look like in ten years? How will an industry dominated by traditional players cope with a new wave of technological innovation and the potential of new entrants? We believe the megatrends will be impossible to miss over the decade: The tightening of fuel economy regulations worldwide, the sustained development of new materials and technologies, an increased focused on safety and the evolving symbiosis between cars and society. In this new series of reports, Cars 2025, we offer insights into the major changes that await the auto industry over the coming decade.

As outlined by Exhibit 1 and detailed in this report, we expect four major themes – Green, Safe, Convenient, and Affordable – to drive seven megatrends for the auto industry over the next ten years.

Seven megatrends to transform industry over next decade

1. **Endless powertrain advancement:** Power train electrification is essential to meeting fuel economy regulations, and we expect the shift to hybrids (HVs), electric vehicles (EVs), and fuel cell vehicles (FCVs) to continue. Improvements to the internal combustion engine (ICE) also cannot be ignored. We expect gasoline/diesel engine vehicles will still make up 75% of global vehicle sales in 2025. Better engine performance is essential to raising the fuel efficiency of HVs and plug-in hybrids (PHVs). We expect a wait-and-see stance on FCVs until 2020.

2. **Autos on a severe diet:** A 50 kg drop in vehicle weight cuts CO2 emission volume by at least 1g per km. Despite efforts by vehicle makers, vehicle weight is trending up. The amount of reinforcement materials needed to meet collision safety standards is rising. For the next 10 years, we expect greater use of aluminum and high-tensile steel to be the main weight reduction measures. Carbon fiber reinforced plastic (CFRP) could be used in the future. According to the GS global steel research team, global steelmakers had EBIT of around US$25 bn from carbon steel in 2014 (we estimate auto-use steel accounted for around 20%-30%).

3. **Autonomous driving on horizon**: Google wants to realize Level 4 vehicle automation or full self-driving by 2017. Most automakers are focusing on Level 3. There are many hurdles to be overcome, including the Vienna Convention and compensation rules in the event of accidents. We believe preventive safety technologies will become standard before 2020 and Level 4 automation will be slower to take hold because of the numerous unknowns over liability and regulations. Preventive safety success will depend on how reasonably devices can be priced.

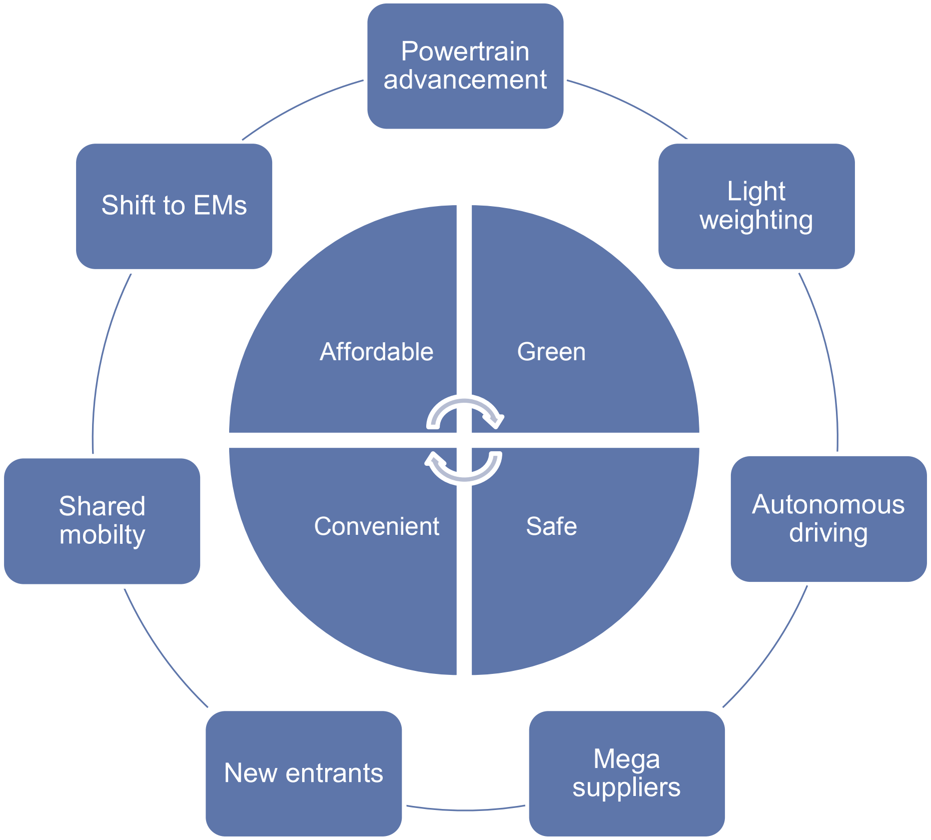
4. **Power shift to mega suppliers:** We estimate that meeting CO2 emission volume regulations will cost automakers US$2,500 per vehicle or US$25bn in total (global automakers generated EBIT of around US$120bn in 2014). This represents a business opportunity for component makers that improves the environmental credentials of vehicles. We expect the presence of mega suppliers to expand as more alliances are formed to reduce upfront cost burdens.

5. **New entrants afoot:** The appearance of autonomous driving and EV is removing auto business entry barriers. Technology companies, including Google and Apple, are showing interest in the auto business. However, outsiders still face many difficult business hurdles, including production system, collision safety, and dealer network issues.

6. **Connected cars and shared mobility:** The use of vehicle position information and running data is likely to increase car share. Vehicle utilization is less than 5% and ownership costs are high. In Shanghai, for example, it costs US$12,000 to acquire a license plate. Connected cars could lead to changes in business models adopted by insurers (which rely on auto insurance for about 30% of revenues).

7. **Shift to emerging markets:** Motorization in emerging markets continues unabated. By 2025, we expect China to have 35 mn vehicles and India 7.4 mn vehicles. Automakers must offer affordable cars that will sell and be profitable, but we see scope for a shift to larger and higher-end vehicles. Amid increasing concern about CO2 emissions, the ability to offer affordable fuel economy technologies will be a major focal point even in various emerging markets.

Exhibit 1: Societal changes to alter the way we use cars
Key megatrends: Green, Safe, Convenient, and Affordable



Source: Goldman Sachs Global Investment Research.

Four key themes

1. Green: Growing pressure to cut CO2 emissions from transport

As the transportation sector accounts for 22% of global CO2 emissions, major developed nations are under pressure to reduce vehicle CO2/kg 30%-40% by 2025. We estimate the ratio of Electrified Vehicles, which includes EVs, PHEVs and HVs, will increase to 25% from the current 5%. In addition, further improvements in the thermal efficiency of internal combustion engines (ICE) will be needed and can yield significant benefits as a 1% improvement in thermal efficiency cuts fuel consumption by 2%-3%. ICE thermal efficiency is now just under 40%, but development of technology that will boost this level to 45%-50% is advancing steadily. Fuel cell vehicles (FCV), which convert hydrogen into energy, have the potential to be the ultimate eco-car. FCV prices should come down dramatically once annual production reaches 50,000 units.

- **22%:** The transportation sector accounts for 22% of global greenhouse gas emissions (2013, METI). With per-capita GDP projected to rise and auto sales volume forecast to reach 120 mn units a year by 2025 (vs. 80 mn in 2015), emissions are set to rise further.

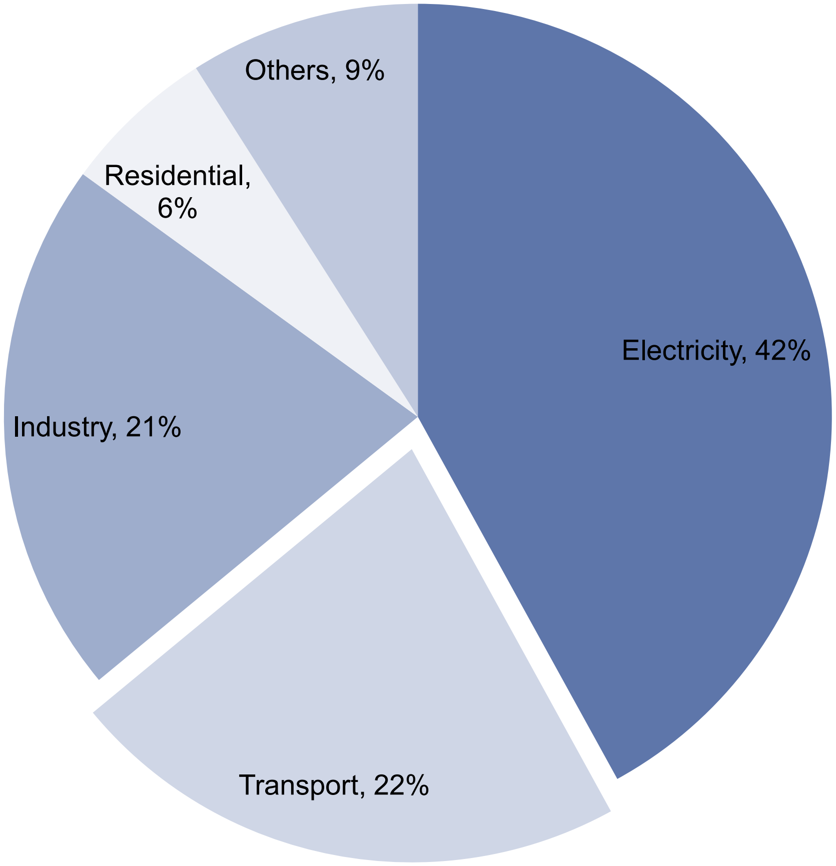
- **1.75X:** Rather than fall, CO2 emissions are projected to increase to 1.75X the 1999 level by 2035. In the meantime, the world's oil is projected to run out in 53 years, with only 1.7 tn barrels left to extract (METI). We expect many governments' energy policy to target a car society that is no longer reliant solely on oil.

- **US$2,500:** We estimate it costs an extra US$2,500 in parts costs per vehicle to comply with CO2 regulations (Japan, US, Europe, and China). With the car CPI in the US not having risen for the past 20 years, automakers will need to cut costs further.

- **¥2.2 mn (US$18,000):** The Japanese government is targeting a ¥2.2mn price tag for FCVs by 2025. Under a mass production structure that would manufacture 50,000 units a year, FCVs could be priced at the same level as a standard hybrid car.

Exhibit 2: The transport sector accounts for a large slice of global CO2 emissions

Greenhouse gas emission by sector



Source: METI, Goldman Sachs Global Investment Research.

2. Safe: Technology and an aging society increase focus on accident prevention

Every year, road accidents claim the lives of about 500,000 people and leave 7 mn people injured. The prospect of reducing this toll is one of the major forces behind the development of semi-autonomous and autonomous vehicles, building from existing safety features such as traction control, stability systems, lane assist and automated braking. A growing need for safe transportation for the elderly adds to the demand, with people over 65 expected to make up 10% of the world's population by 2025. In addition, we expect automakers to further strengthen vehicle frames to enhance safety during collisions. We see collision safety technology as a competitive edge at existing manufacturers as companies from various industries compete for a place in the market using new technology.

- **7 mn people**: Every year, 7 mn people are injured in traffic accidents worldwide and 500,000 lose their lives, according to Japan's Ministry of Internal Affairs and Communications.

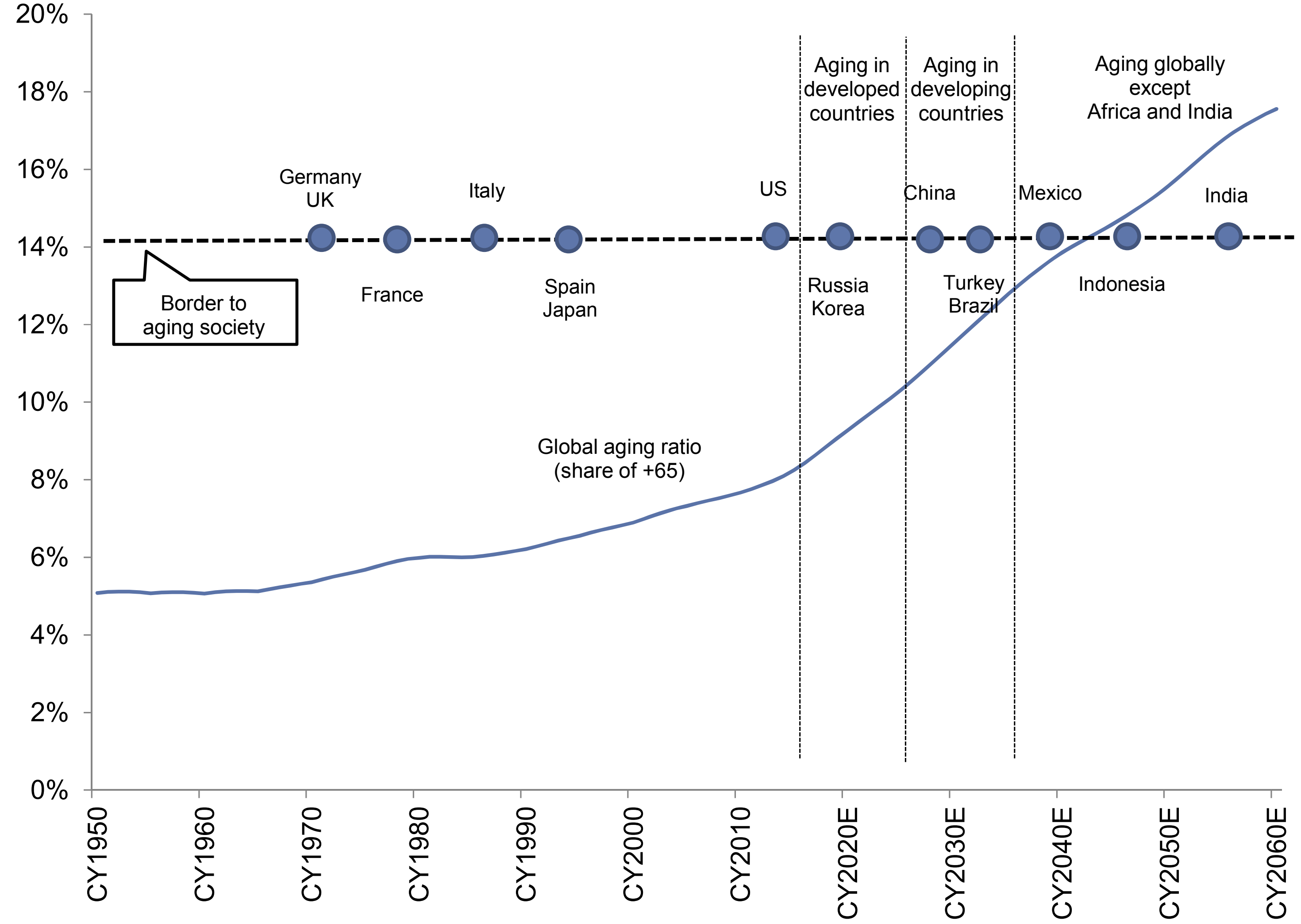
- **10%**: By 2025, the OECD projects 10% of the world's population will be over 65 (20% by 2060).

- **35%**: According to estimates by the GS US financials research team, auto insurance is a core business for insurers, accounting for 35% of their total insurance premiums. This high weighting is testament to the risks associated with driving a car.

- **44%**: According to polls conducted in Germany, France and Italy in 2012, 44% of respondents expected autonomous driving to make cars safer.

Exhibit 3: Population aging is becoming a global phenomenon

Countries where more than 14% of the population is 65 or older



Source: OECD, Goldman Sachs Global Investment Research.

3. Convenient: Reducing traffic, freeing drivers and cutting waste

The world's urban population is expected to grow 50% to 6 bn people by 2050. With traffic congestion getting worse and the driving environment growing more complex, fewer drivers are likely to view driving as a source of fun. Car ownership costs are rising steadily, while cars sit unused 95% of the time. These conditions create an opportunity for disruption from autonomous cars and car-sharing services to more efficiently use resources. With that comes the prospect that fewer cars will be needed to serve a larger number of passengers in urban areas as car utilization increases.

- **6 bn people:** The world's urban population is projected to grow to 6 bn by 2025 (and the rural population to 2 bn). This would mark a 50% increase from the level of 4 bn in 2010.

- **41 cities:** The urbanization of the global population is advancing. The number of so-called mega cities—cities with populations of more than 10 mn—was 28 in 2014 and is forecast to increase to 41 in 2030. Urban density may be an important factor in determining where car sharing is effective because of the ability to match vehicles with passengers in close proximity.

- **300-400 hours:** Americans/Japanese and Europeans spend 300-400 hours in their cars every year. How they pass the time may be about to change appreciably.

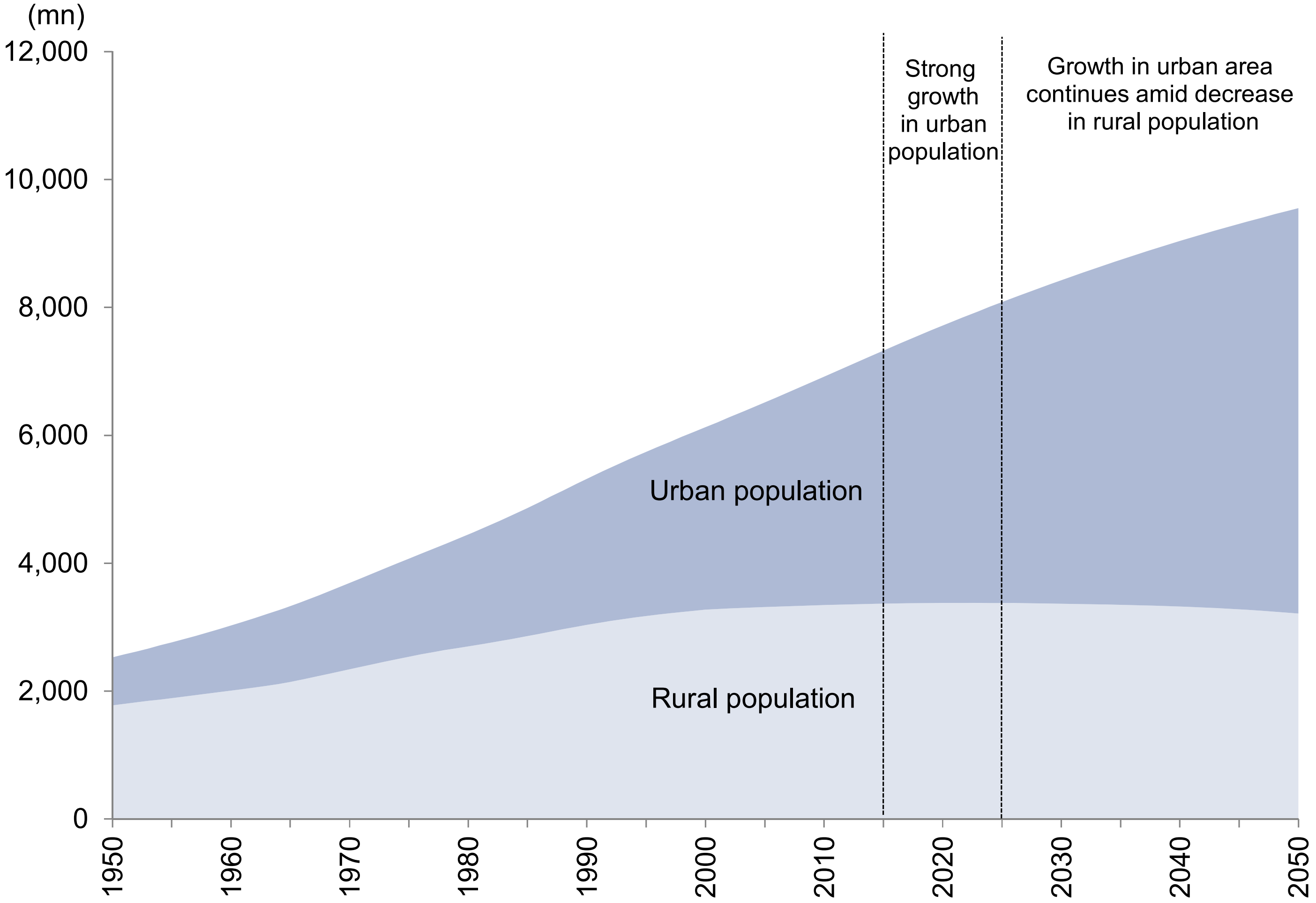
- **30 hours:** The average person in Japan spends 30 hours every year in traffic jams. The resulting economic loss is estimated at more than US$100 bn. Although no global statistics are available, it is not hard to imagine the significant opportunity losses that are likely occurring.

- **2017:** Google has said 2017 will be the year it brings driverless vehicles capable of full autonomy (Level 4) to the market. Other companies are developing self-driving cars with an eye to launches in 2020-2025.

- **3%:** In Japan, we estimate the utilization rate for cars is only 3%. If this percentage were to rise even slightly, car ownership (now 60 mn vehicles) could change dramatically. If autonomous driving were to become a reality, the need for each person to own a car would diminish.

Exhibit 4: Urbanization trend to continue

Global urban and non-urban population



Source: OECD.

4. Affordable: Meeting developing markets demand for reasonably priced cars

We forecast global auto sales will increase from 80 mn units in 2015 to 100 mn units in 2020 and 120 mn units in 2025, and we expect developing nations to account for almost all of this growth. This is because we expect per-capita GDP to reach US$10,000-US$20,000, the level at which motorization generally gains real momentum, in some developing markets around 2025. This is likely to require a business model that generates profits from small cars that are reasonably priced. Attitudes to vehicle ownership could also change in various markets and government fees and restrictions may reduce affordability in an effort to curb growth and fight congestion and pollution.

- **120 mn vehicles:** Global auto sales volume is forecast to reach 120 mn units by 2025, driven by demand in developing markets.

- **35mn:** China alone is projected to account for 35 mn sales by 2025, despite a slowdown in annual sales growth.

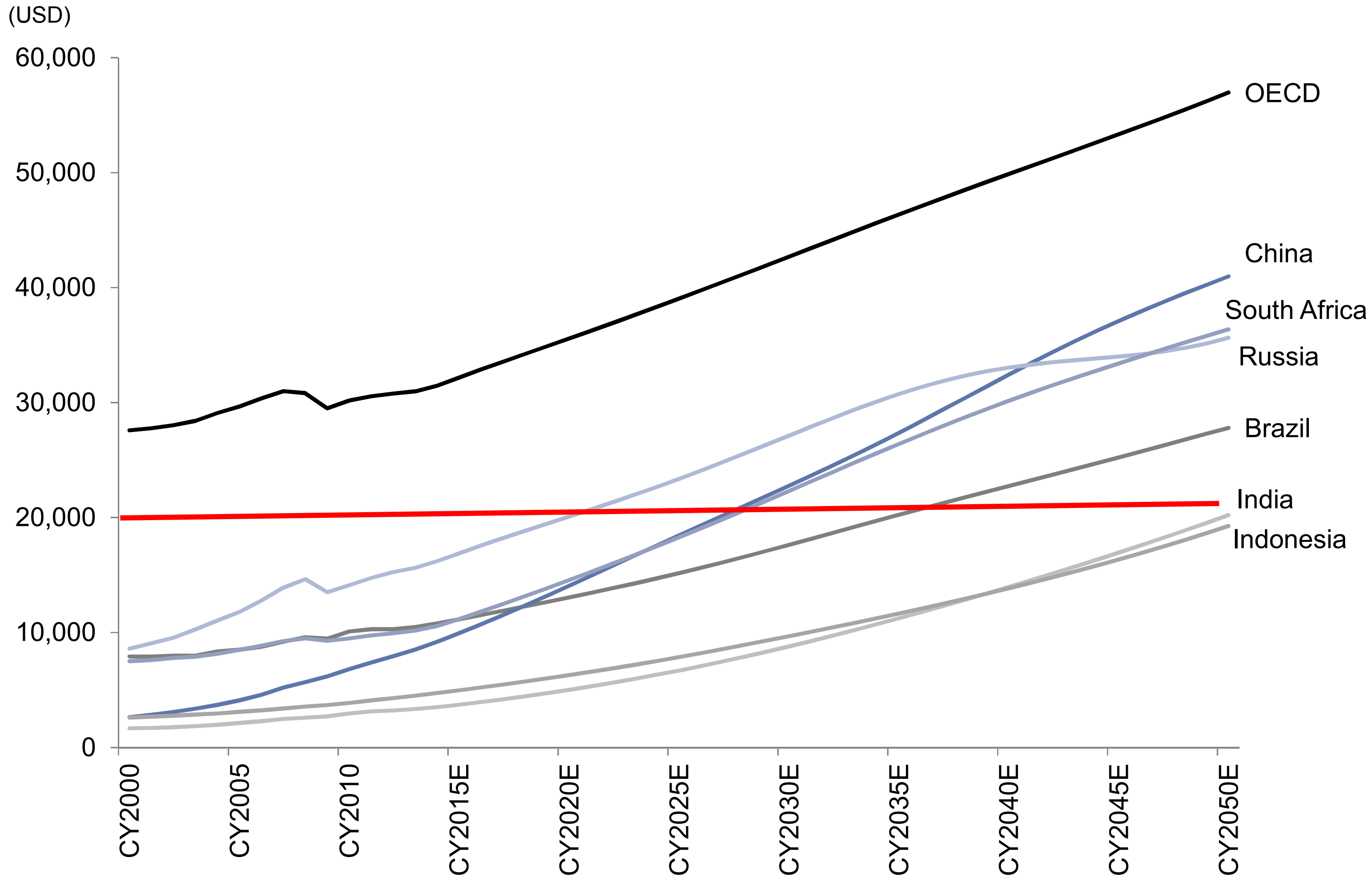
- **US$10,000:** In some Chinese cities, it costs US$10,000 to purchase a license plate, compared with a mere US$69 in California as China seeks to curb congestion and fight pollution. Restrictions on car ownership and increased fees helped slow growth in retail sales of passenger cars to 13.2% last year from 19.7% the previous year.

- **7.4mn:** India is poised to become the third-largest market for autos by 2025 as incomes rise, even with GDP per capita projected at US$3,500.

- **27:** India has a median age of 27, compared with 38 in the US and 37 in China. Younger people in Indian cities may be less inclined to own cars as their incomes rise because of increasing options for taxi-on-demand, self-drive rentals and ride sharing.

Exhibit 5: Motorization is unstoppable

Per capita GDP



Source: OECD.

Seven megatrends for the next decade

1. Endless powertrain advancement

No postponing regulatory tightening

Fuel economy regulations could tighten intermittently between 2020 and 2025, mainly in the US and Europe. The US corporate average fuel economy (CAFE) target of 54.5 MPG for the 2025 model year and the possible European CO2 emission target of 72g/km by 2025 (not officially decided yet) represent very challenging hurdles for automakers. China has decided to tighten fuel efficiency standards in response to increasing environmental problems, a heavy reliance on overseas energy (already more than 50%), and urban traffic congestion.

California ZEV regulations heading to a new phase in 2018; PHEVs, FCVs and EVs likely to gain in importance

In addition to regulations at the national level, the regulatory drive is also evident in the US at the state level. Zero emission vehicle (ZEV) regulations announced by the State of California apply to hybrids in the ZEV category through 2017, but from 2018 the regulations will only include PHEVs, EVs, and FCVs. In 2018, ZEV credits will be indexed to each vehicle's quick charge time. We believe smaller EVs with faster charge times will benefit the most, and we see further expansion for the product segment that includes GM's Bolt prototype. Several other states, including New York, plan to introduce ZEV regulations, making the technical hurdles for automakers even more severe.

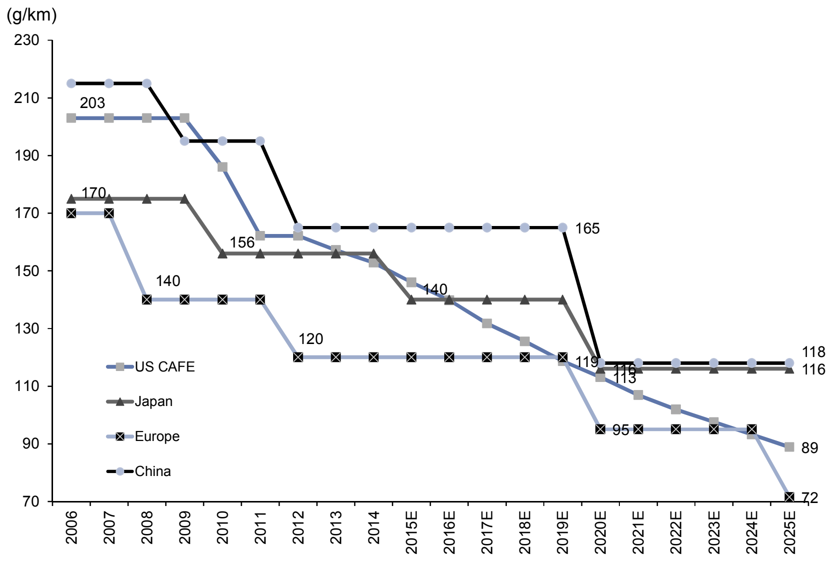
Progress toward int'l harmonization of vehicle test procedures

Parallel with the roadmap for fuel economy regulations, discussions are underway in Japan, the United States and Europe about creating a uniform vehicle test mode for measuring fuel economy. Designed to more closely represent real-world fuel economy performance, the World-Harmonized Light-Duty Vehicles Test Procedure (WLTP) could lead to a reduction in test mode fuel economy (we expect actual WLTP introduction will be around 2020). WLTP differs from Japan's JC08 mode in various ways. While removing the complexities involved in performing several measurements of fuel economy depending on various countries' standards would be a positive, WLTP constitutes a clear headwind to meeting fuel economy regulations, in our view.

Accelerating vehicle electrification essential to reach 2025 targets

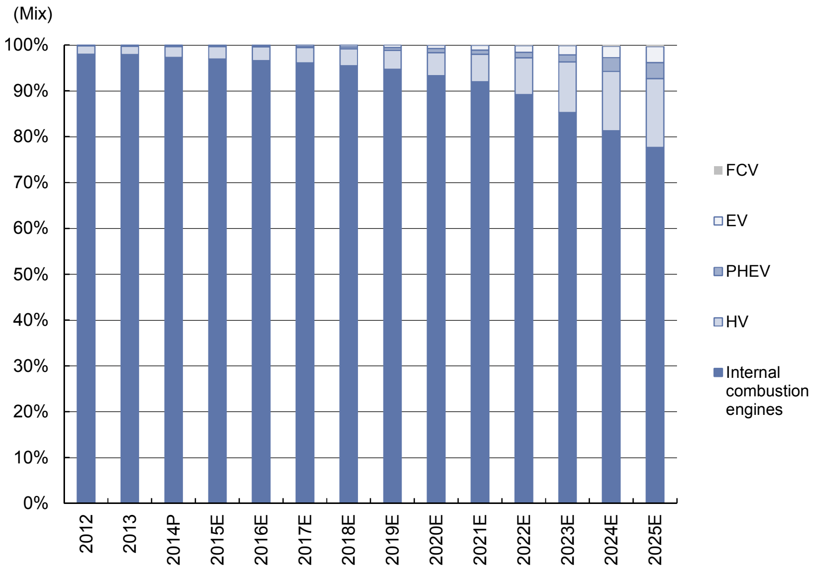
We forecast vehicles with an electric powertrain system will account for 25% of global auto sales in 2025, up from 5% in 2015. While we expect hybrids to be the main type of electrified vehicle, we believe PHEV penetration is likely to accelerate in Europe, California, and other markets. Japan and Germany are considering generous subsidies for FCV, and we see potential for FCV demand to expand, albeit on a localized basis.

Exhibit 6: Intermittent tightening of fuel efficiency standards
CO2 emission standards in major countries



Source: JAMA, DOE, Goldman Sachs Global Investment Research.

Exhibit 7: In order to meet CO2 standards, electrification will be essential
% of sales by powertrain



Source: IHS, Goldman Sachs Global Investment Research.

Conventional engine innovation cannot be ignored

While vehicle electrification has become a major auto market theme, the GS global auto research team forecasts cars with conventional gasoline/diesel engines will still account for 75% of global auto sales in 2025. Improvements in conventional engine technology will also be needed to raise the fuel efficiency of HVs and PHEVs. Steady advances in direct fuel injection, turbo downsizing, and cylinder management technologies continue to improve conventional engine performance.

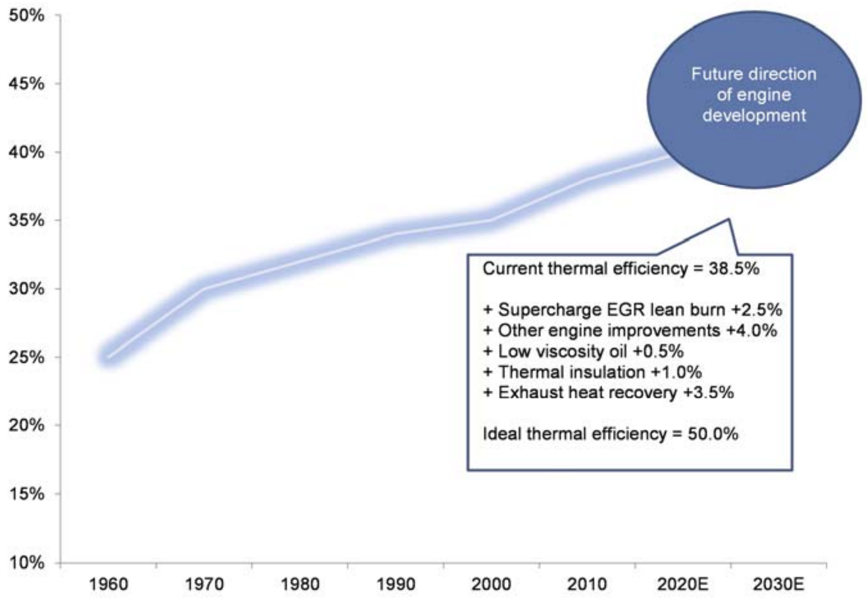
Why engine thermal efficiency is attracting attention

Thermal efficiency is one factor that is critical to engine performance. Currently, thermal efficiency stands at just under 40%, but an improvement to 45% in five years and 50% in 10 years is coming within view as R&D advances. Of course, efforts to boost engine thermal efficiency are not a recent development, but engines are being used more efficiently now as a result of transmission evolution (the transition to continuously variable transmissions [CVT] and multi-speed automatic transmissions) and advances in hybrid technology. Every 1% improvement in thermal efficiency generally translates into a 2%-3% improvement in fuel efficiency, so a 10% increase in thermal efficiency would improve fuel efficiency in existing engines by around 20%-30%. Thus, it is theoretically possible to achieve fuel efficiency on par with HVs through engine enhancements alone.

We focus on engine downsizing and HCCI

We highlight engine downsizing and homogeneous charge compression ignition (HCCI) engine technologies. Engine downsizing refers to the use of a turbo inlet system to achieve powerful driving with only small engine displacements. European makers are leading in this space. For turbos, automakers are further improving capacity by adopting electric superchargers, and we are watching closely for future trends. Looking beyond 2020, we believe HCCI gasoline engines that work through auto-ignition will be worthy of attention. European automakers and Japanese automakers are competing in R&D in this space, which may offer the prospect of reducing fuel costs by about 30% compared with current models. Automakers are seeking to improve engine characteristics, especially in terms of stable engine operation under low temperatures.

Exhibit 8: Thermal efficiency directly linked to fuel consumption
Thermal efficiency improvement scenario



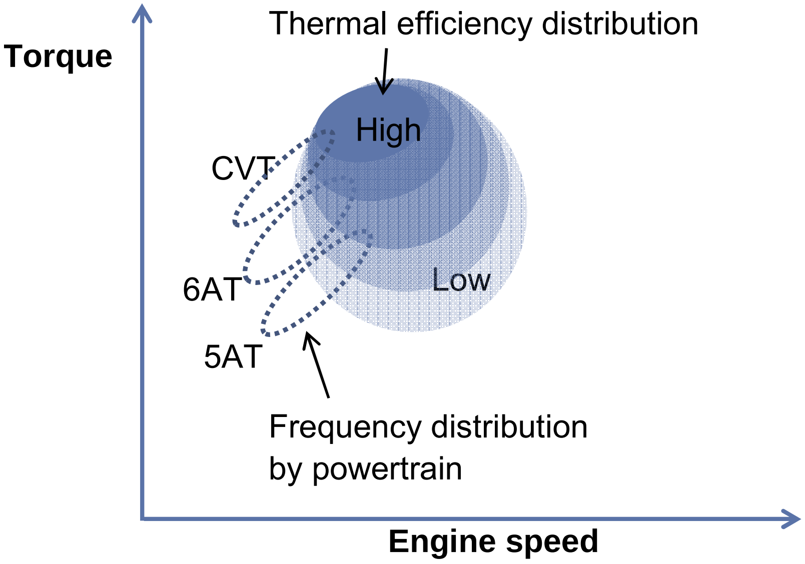
Current thermal efficiency = 38.5%

+ Supercharge EGR lean burn +2.5%
+ Other engine improvements +4.0%
+ Low viscosity oil +0.5%
+ Thermal insulation +1.0%
+ Exhaust heat recovery +3.5%

Ideal thermal efficiency = 50.0%

Source: Toyota, Goldman Sachs Global Investment Research.

Exhibit 9: Transmission advancement
Thermal efficiency and transmission


Torque
Thermal efficiency distribution
High
CVT
6AT
Low
5AT
Frequency distribution by powertrain
Engine speed

Source: Toyota,

EV vs. FCV view is mistaken; they can coexist as technologies

The arrival of FCVs is often discussed in opposition to EVs. However, we believe the two technologies can coexist and should not be viewed as an either/or choice. FCVs have the advantage of longer driving ranges and shorter fill-up times (three minutes), but also the disadvantages of vehicle size restrictions and hydrogen infrastructure development. EVs have the advantage of simple construction of charging stations, but the disadvantages of driving ranges and battery degradation. In fact, EV driving ranges are limited to around 100 miles, with the exception of some high-end models. We believe the use of FCVs and EVs could differ depending on the driving distance needs of consumers.

Are FCVs the ultimate eco-car?

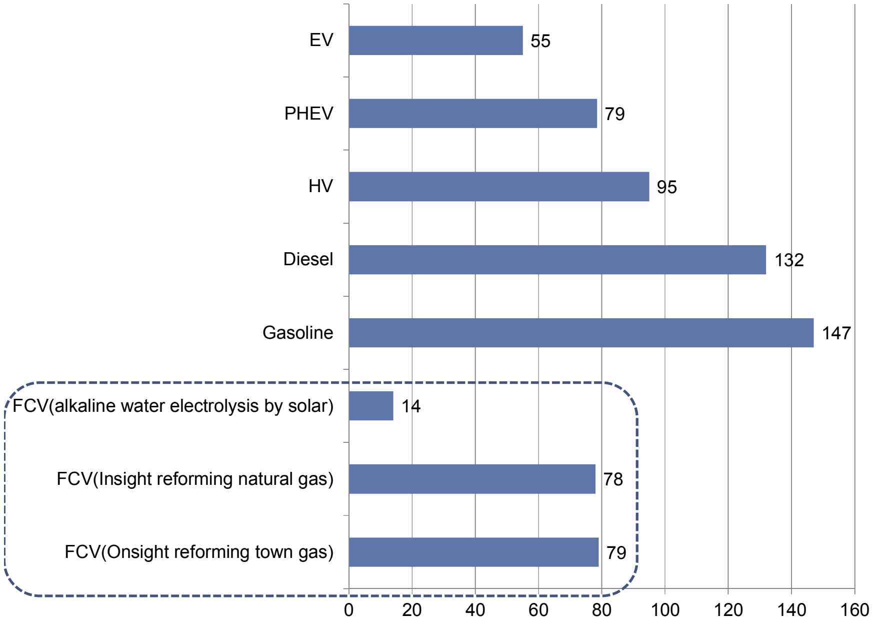
Toyota released the world's first mass-production FCV, the Mirai, in December 2014, calling FCVs the ultimate eco-car. There are many obstacles to FCV penetration, including a lack of hydrogen infrastructure, well-to-wheel CO2 emission volume, and relatively high vehicle prices, but Japan, Korea, and California have announced that they intend to actively develop this market. If a way to effectively use byproduct hydrogen (generated in steel and petrochemical production processes) can be found, resources would not be wasted on hydrogen production. In contrast, if fossil fuel modification and water electrolysis processes were adopted, manufacturing costs would be high, and FCVs would not contribute much to CO2 reduction. However, if hydrogen produced from solar alkaline or other renewable energy sources were used, we believe the ultimate eco-car moniker would be deserved.

Penetration key for FCV; price target of ¥2.2 mn by 2025

No matter how good the technology, if FCVs do not gain market traction they will not make a meaningful contribution to CO2 reduction. Expensive eco-cars will not be much help in this regard, and at current prices (around ¥7 mn in Japan) the likelihood of FCV market penetration is low. First-generation models in 2015 will probably not find a big market. Second-generation models, which we expect to be released around 2020, could attract more interest (this was the case with the Prius, which was first released in 1997). We estimate the fuel-cell stack, the most expensive FCV component, now costs around US$300 per kWh. At annual production of 50,000 units, we estimate economies of scale could reduce this cost to US$67/kWh. The Mirai has a stack capacity of 114 kWh, which at current levels costs just over US$30,000 to make. This cost could potentially decline to US$7,000 if production volume were large enough. The Japanese government is targeting a price of ¥2.2 mn for FCVs in 2025, which would put FCVs on par with other popular HVs.

Exhibit 10: Some hydrogen production processes generate CO2

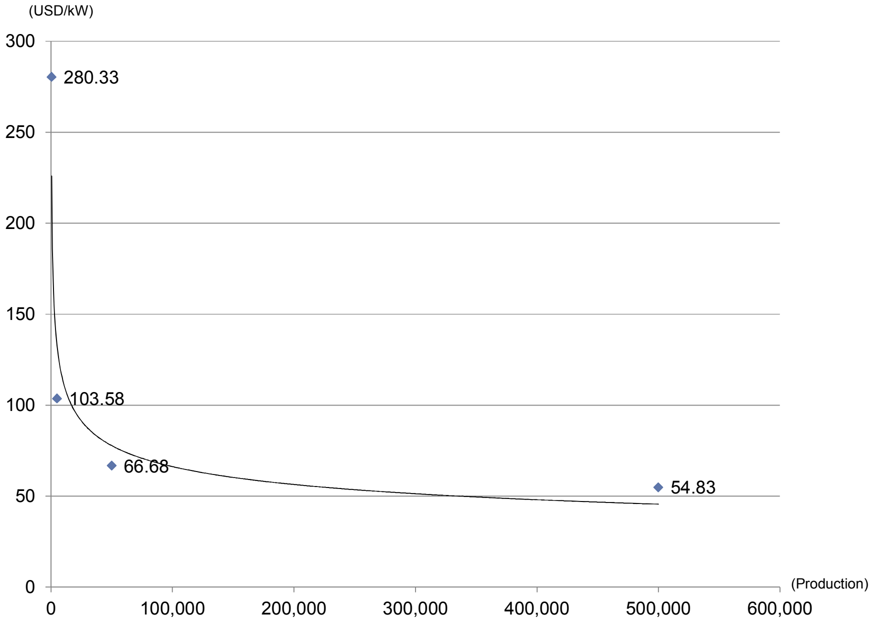
Comparison of CO2 emissions (g/km)



Source: METI,

Exhibit 11: Volume production drastically reduces FCV costs

Fuel stack cost curve



Source: DOE, Goldman Sachs Global Investment Research.

Exhibit 12: Stocks in focus

Powertrain

Company	Ticker	Region	Market Cap. (US$, mn)	Comment
ICE advancement				
Engine management system				
Denso	6902.T	Japan	46,124	Global No.1 revenue auto parts makers. Toyota has 22% stake.
Delphi	DLPH	US	24,647	High tech auto parts maker.
Continental	CONG.DE	Germany	47,501	High tech auto parts maker. It has high end tire business as well.
Keihin	7251.T	Japan	1,226	High tech auto parts maker. Honda has 41.3% stake.
Hyundai Mobis	012330.KS	South Korea	20,802	High tech auto parts maker. Hyundai/Kia are its main customers.
Bosch	Non-listed	Germany	-	Global No.2 revenue auto parts maker.
Turbo				
Mitsubishi Heavy	7011.T	Japan	20,462	World top 3 turbo charger maker.
IHI	7013.T	Japan	7,169	World top 5 turbo charger maker.
Honeywell	HON	US	81,642	World top 3 turbo charger maker.
BorgWarner	BWA	US	13,866	World top 3 turbo charger maker.
Valeo	VLOF.PA	France	13,171	Global automotive suplier. Supplies electric super charger.
Transmission				
Aisin	7259.T	Japan	13,434	World top 3 automatic transmission maker. Toyota has 22% stake.
ZF	Non-listed	Germany	-	World top 3 automatic transmission maker.
JATCO	Non-listed	Japan	-	Global No.1 CVT maker. Nissan has majority stake.
Schaeffler	Non-listed	Germany	-	World top 3 automatic transmission maker.
Fuel Cell Vehicle				
OEMs				
Toyota	7203.T	Japan	234,883	First mass produced FCV producer for retail customers.
Honda	7267.T	Japan	61,510	Aiming to launch FCV (mass production) in early 2016.
Nissan	7201.T	Japan	46,547	Aiming to launch FCV (mass production) in 2017.
Hyundai	005380.KS	South Korea	32,836	Already started FCV fleet sale.
Volkswagen	VOWG_p.DE	Germany	74,673	Aiming to launch FCV (mass production).
Hydrogen station				
Iwatani	8088.T	Japan	1,724	Japanese No.1 hydrogen maker. Operates several hydrogen stations in Japan.
Taiyo Nippon Sanso	4091.T	Japan	5,335	Operates several hydrogen stations in Japan.
JX Nippon Oil & Energy	5020.T	Japan	10,960	Operates over 40 hydrogen stations in Japan.

Source: Datastream, Goldman Sachs Global Investment Research.

2. Autos on a severe diet: New materials to reduce car weights

Collision safety standards getting stricter; barrier to market entry

While a focus on preventive safety is understandable, collision safety standards are becoming stricter every year. To improve passenger safety, vehicle chassis strength tests are being expanded to include side and head-on collisions. Rear-collision test standards (speeds) are also becoming stricter. The ability to make extremely robust molded parts could be an unforeseen barrier to entry for companies from other industries. Google driverless test cars made by Roush, a Detroit-area company, have a maximum speed of 40 km/hour according to Nikkei Automotive. There have been media reports that Apple will enter the auto business and is considering Asian EMS companies as production partners. Whether Apple will be able to procure vehicle bodies with sufficient strength will be a point to watch.

Exhibit 13: Safety standard varies country to country

Safety assessment

	JNCAP (Japan)	U.S. NCAP (US)	IIHS (US)	Euro NCAP (Europe)	C-NCAP (China)
Fulllap rigid barrier	Speed: 55km/h Dummy: Hybrid III×2 (Male 2)	Speed: 56km/h (35mph) Dummy: Hybrid III×2 (Male and female 1 each)	×	Speed: 64km/h Dummy: Hybrid III×3 (Female 3)	Speed: 50km/h Dummy: Hybrid III×2 (Male and female 1 each)
Offset deformable barrier (passenger seat)	Offset ratio: 40% Speed: 64km/h Dummy: Hybrid III×2 (Male and female 1 each)	×	Offset ratio: 40% Speed: 64km/h Dummy: Hybrid III×1 (Male)	Offset ratio: 40% Speed: 64km/h Dummy: Hybrid III×2 (Male) , Q1.5×1 (1.5yrs old, assistant's back seat), Q3×1 (1.5yrs old, passenger back seat)	Offset ratio: 40% Speed: 64km/h Dummy: Hybrid III×3 (Male 2, Female 1)
Small overlap barrier (passenger seat)	×	×	Offset ratio: 25% Speed: 64km/h Dummy: Hybrid III×1 (Male)	×	×
Moving deformable barrier (passenger seat)	Barrier weight: 950㎏ Speed: 55km/h/90° Dummy: ES-2×1 (passenger front seat)	Barrier weight: 1,368㎏ Speed: 62km/h/27° Dummy: ES-2 re×1 (passenger front seat), SID IIs×1 (passenger back seat)	Barrier weight: 1,500㎏ Speed: 50km/h/90° Dummy: ES-2 re×2 (passenger front seat, passenger back seat)	Barrier weight: 950㎏ Speed: 50km/h/90° Dummy: ES-2×1 (passenger front seat), Q1.5×1 (1.5yrs old, passenger back seat), Q3×1 (1.5yrs old, assistant's back seat)	Barrier weight: 950㎏ Speed: 55km/h/90° Dummy: ES-2×1 (passenger front seat)
Pole	×	Speed: 32km/h/75° Dummy: SID IIs×1	×	Speed: 29km/h/90° Dummy: ES-2×1	×
Others	Whiplash mitigation	SUV rollover	Roof crush Whiplash mitigation	Pedestrian test Whiplash mitigation	Whiplash mitigation

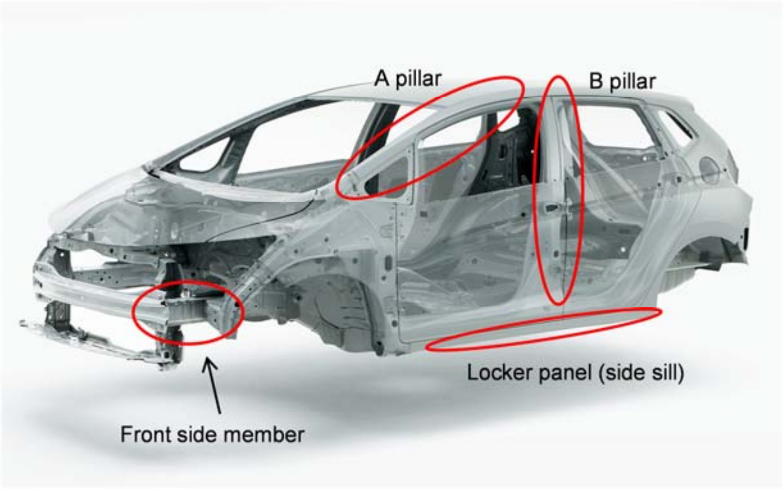
Source: IHS, company interviews, Goldman Sachs Global Investment Research.

Until recently collision safety & weight reduction have been at odds

We believe global automakers plan to reduce vehicle body weight in 2020-2025, but the obstacles to weight reduction are formidable. The new Hyundai Sonata, which underwent a full-model makeover in 2014, was actually heavier than the previous model. Also, collision tests adopted by the NCAP, IIHS, and other standards organizations are becoming tougher, and it appears automakers will have to use more reinforcement materials in vehicle bodies. Vehicles could therefore become heavier. We believe the use of high-tensile steel, aluminum, and carbon fiber reinforced plastic (CFRP) in vehicles will definitely increase over the next 10 years.

Exhibit 14: Key components for collision safety

Body structure



Source: Honda, Goldman Sachs Global Investment Research.

Exhibit 15: Developments in high-tensile steel

Historical usage of high-tensile steel

	1995	2000	2015	Features
Front side member	270/440	590	780/980	Front-impact
A pillar	440	590	980/1200/hot-press	Load transfer
Locker panel	590	780	980/1200/hot-press	Side-impact
B pillar	590	780	980/1200/hot-press	Side-impact
Doors	270/340	340	340/440	Dent resistance

Source: Company interview, Goldman Sachs Global Investment Research.

High-tensile steel and aluminum to be preferred

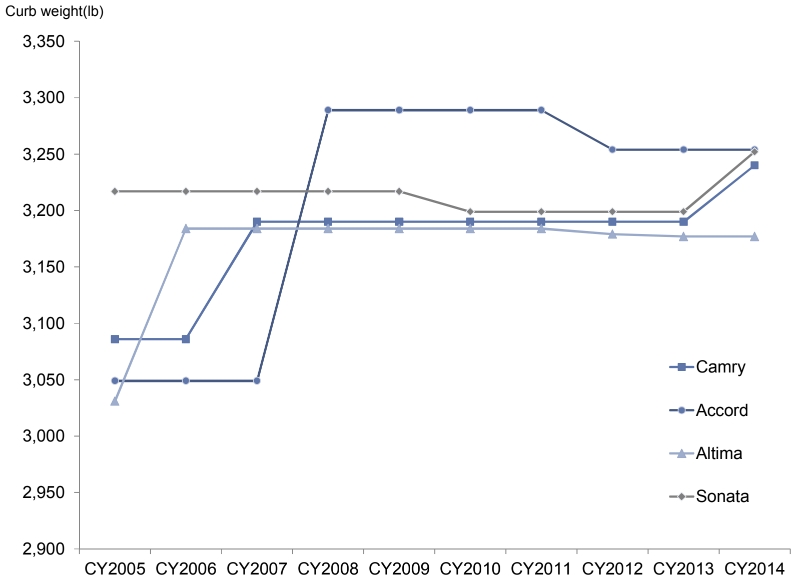
We expect high-tensile steel and aluminum to be the preferred materials for weight reduction because using them entails a small additional capex burden for automakers. Existing press lines can be converted to handle aluminum (depending on the part), and welding robots for bonnets, doors, and other exterior panels that have few welds with steel can be modified without significant investment. CFRP is a superior material, but costs US$40/kg compared with US$2/kg for high-tensile steel and US$6/kg for aluminum alloy.

Development of 1180 MPa high tensile materials; Japan steelmakers have edge

Steelmakers began mass production of 1180 MPa high-tensile sheets about four to five years ago (we calculate a weight reduction of about 5%-10% more than with 980 MPa sheets), leveraging their world-class high-tensile sheet technology. Although challenges remain, especially in terms of whether global supply systems can be put in place (e.g., Nippon Steel and Sumitomo Metal and ArcelorMittal will begin mass production in the United States from this summer) or whether automakers will have multiple vendors at their disposal as rival steelmakers follow suit, advances in high-tensile materials are crucial to strengthening key auto body components.

Exhibit 16: Car diet not going according to plan

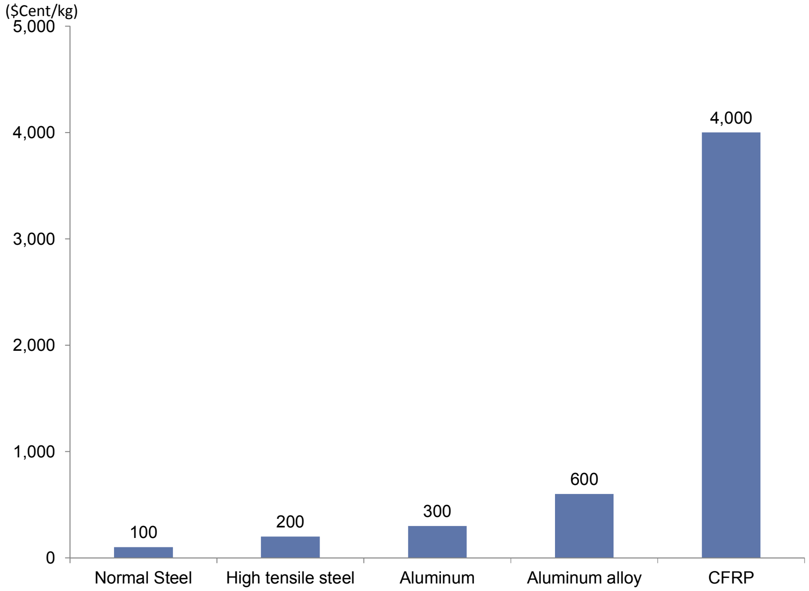
Body weight trends for mainstay US models



Source: Company data.

Exhibit 17: New materials relatively expensive, used only in high-end vehicles

Comparison of auto materials prices

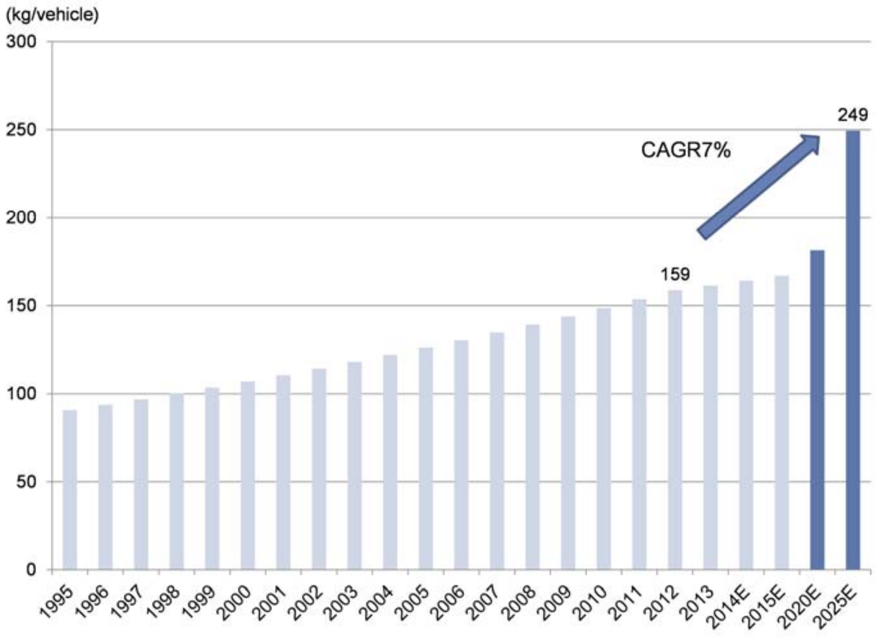


Source: Company interview, Goldman Sachs Global Investment Research.

Expanding use of aluminum for exterior panels in larger cars

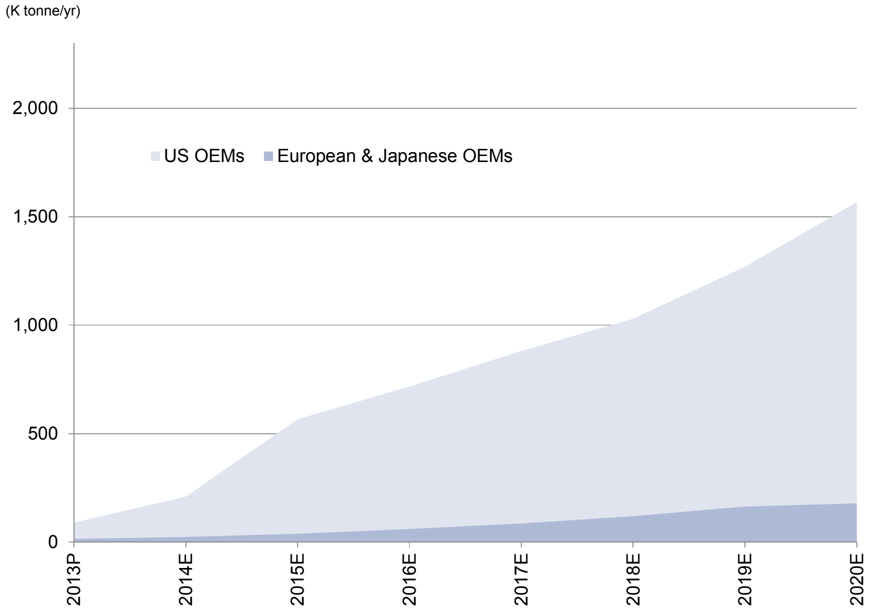
Our US metals analyst Sal Tharani estimates that 159 kg of aluminum was used per vehicle in North America in 2012 and that this will rise 7% annually to 249 kg in 2025. Aluminum now accounts for 5%-10% of a vehicle’s weight, but Tharani believes this is likely to rise to nearly 15% by 2025. Tharani forecasts that Ford and other US/European automakers will be the main users of aluminum. It is relatively easy for aluminum suppliers to reconfigure manufacturing lines for beverage can production to make aluminum for automotive use, and the ability to repurpose most of their existing plants allows for quick decision-making.

Exhibit 18: Aluminum usage will grow at 7% CAGR in US
Aluminum usage per vehicle in US



Source: Company data. Goldman Sachs Global Investment Research.

Exhibit 19: Expansion driven by US OEMs.
Aluminum usage among automotive industry



Source: Company interview, Goldman Sachs Global Investment Research.

CFRP is a longer-term theme

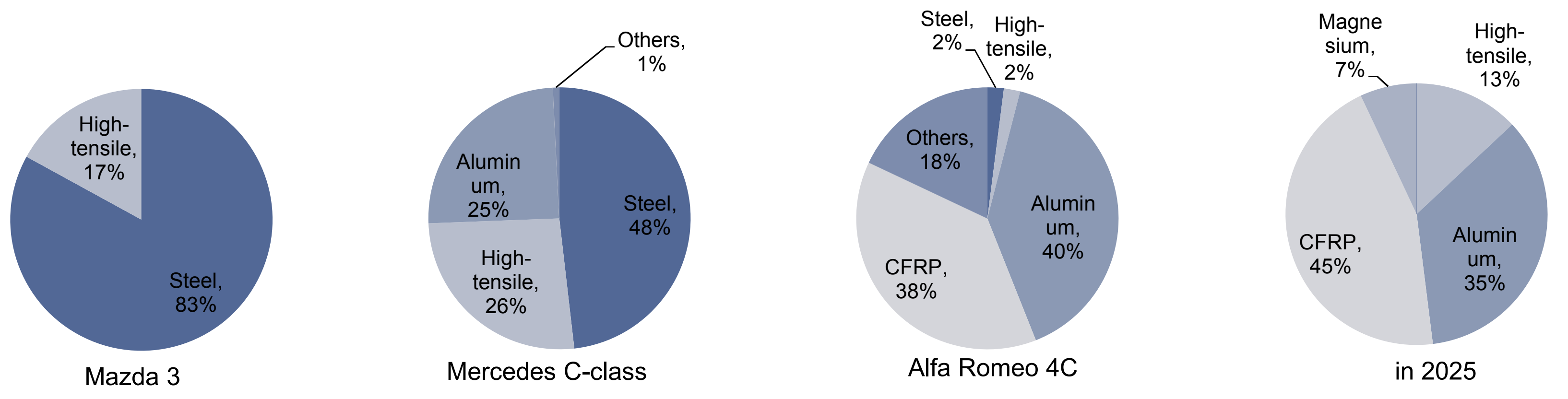
Changes have been taking place in the materials used in auto bodies, from steel to high-tensile steel to aluminum alloys, and another material that may be used in the future is carbon fiber reinforced plastic (CFRP). CFRP use is currently limited to sports cars made in small volumes. CFRP is even more expensive than aluminum alloys, with a price of US$40/kg, and it takes longer to make and is much more difficult to repair following accidents. We do not see it as a suitable material for large-volume production at this time.

Use of multi-materials may add to downward pressure on steel makers' profit

Global steelmakers had EBIT of around US$25bn in 2014. While there is no profit breakdown by application, we estimate auto-use steel accounted for around 20%-30% of the profits of Japanese steelmakers. If the auto industry increases the use of aluminum and CFRP, it could reduce the profit pool. Steelmakers have a strong incentive to advance high-tensile steel technologies to protect their business.

Exhibit 20: Era of multi material

Auto body material trend



Source: Nikkei Automotive

Exhibit 21: Stocks in focus

Light-weight auto materials

Company	Ticker	Region	Market Cap. (US$, mn)	Comment
Light Weight				
Hight-tensile steel				
JFE Holdings	5411.T	Japan	14,464	Japanese steel manufacturer. Has core strength in high tensile steel.
NSSMC	5401.T	Japan	25,305	Japanese steel manufacturer. Has core strength in high tensile steel.
Kobe Steel	5406.T	Japan	6,720	Japanese steel and aluminum supplier. It has 50% of auto body aluminum share in Japan.
US steel	X	US	3,646	US major steel manufacturer.
POSCO	PKX	South Korea	19,835	Korean major steel manufacturer.
Hyundai Steel	004020.KS	South Korea	8,126	Korean major steel manufacturer.
ArcelorMittal	MT	Luxembourg	18,387	World's leading steel producer.
Aluminum				
UACJ	5741.T	Japan	1,157	Japanese aluminum supplier. It has 50% of auto body aluminum share in Japan.
Kobe Steel	5406.T	Japan	6,720	Japanese steel and aluminum supplier. It has 50% of auto body aluminum share in Japan.
Alcoa	AA	US	15,818	World top 5 aluminum supplier.
Constellium	CSTM	Netherland	1,566	World top 5 aluminum supplier.
Novellis	Non-listed	US	-	World top 5 aluminum supplier.
CFRP				
Toray	3402.T	Japan	13,729	CFRP manufacturer. Hold Toray Carbonmagic as a subsidary.
Teijin	3401.T	Japan	3,641	CFRP manufacturer. Hold TohoTenax as a subsidary.
Mitsubishi Chemical	4188.T	Japan	9,671	CFRP manufacturer. Hold Mitsubishi Rayon as a subsidary. Main supplier for i3, first commercial BMW EV.

Source: Datastream, Goldman Sachs Global Investment Research.

3. Autonomous driving on horizon: 2017 should be watershed year

Driving can sometimes be far from pleasurable these days

The auto industry frequently references the pleasure of driving in its advertising, but being trapped in traffic is anything but pleasurable. Many people are painfully aware of what driving in cities is like. Japanese people are estimated to spend 40 hours per year stuck in traffic on average (the figure would be much higher if calculated based on the actual number of drivers), and the Ministry of Land, Infrastructure and Transport (MLIT) estimates this results in economic opportunity losses of more than US$100 bn annually. Comparable global statistics are not available, but it seems clear that traffic congestion results in enormous opportunity losses.

Self-driving cars may someday rescue time once wasted in traffic

Daimler announced its F 015 Luxury in Motion concept car at the January 2015 Detroit Auto Show. The car is equipped with a driver's seat, but the seats are arranged so that four people can sit facing each other and talk or read as they are traveling. The company envisions new value created by cars in line with its concept of cars being a "mobile living space." Even long-established automakers are focusing on the idea that autonomous driving will enable people to make efficient use of the time they currently waste driving. Every year, the average American spends 300-400 hours driving vs. 800 hours surfing the internet and 1,000 hours talking on their mobile phone.

Vienna Convention a roadblock to autonomous driving

The articles in the Vienna Convention on Road Traffic outlined below constitute a roadblock to autonomous driving. While national governments cooperate with the United Nations in formulating rules of the road, actually changing laws would probably take several years.

Article 8: Drivers

1. Every moving vehicle or combination of vehicles shall have a driver... 3. Every driver shall possess the necessary physical and mental ability and be in a fit physical and mental condition to drive... 5. Every driver shall at all times be able to control his vehicle or to guide his animals.

Article 13: Speed and distance between vehicles

1. [Every driver] shall, when adjusting the speed of his vehicle, pay constant regard to the circumstances, in particular the lie of the land, the state of the road, the condition and load of his vehicle, the weather conditions and the density of traffic, so as to be able to stop his vehicle within his range of forward vision and short of any foreseeable obstruction.

Level 4 software risks cannot be ignored

We believe software challenges cannot be ignored for Level 4 fully autonomous cars to become a reality. A failsafe method to deal with a bug or a system shutdown caused by either an external or internal factor is needed to answer product liability concerns and address how traffic will be managed. As a result, we believe there is a strong incentive for conventional automakers to focus on Level 3 automation for the time being.

Exhibit 22: Steps toward full self-drive automation
Four autonomous driving levels

Autonomous Lv.	Outline	System
Level 1	Either one of the acceleration/handling/control would be done by automobile.	Safety assistance
Level 2	Either 2-3 of the acceleration/handling/control would be done by automobile.	Semi-autonomous driving
Level 3	The acceleration/handling/control would be done by automobile and a driver could take over control in emergency situation.	Semi-autonomous driving
Level 4	The acceleration/handling/control would be done by automobile and no involvment of a driver.	Autonomous driving

Source:: Goldman Sachs Global Investment Research.

Exhibit 23: Support from around half of those surveyed
Autonomous driving opinion poll (Europe)

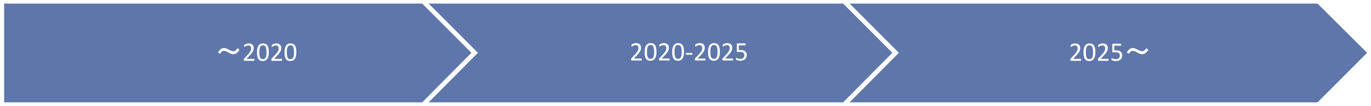
	Avg.	Germany	Frace	Italy
Good idea (if autonomous driving would still allow control by driver)	60%	52%	63%	65%
Understandable as the next stage of drive assistance	54%	56%	50%	55%
Technologically possible	50%	52%	48%	48%
Makes driving safer	44%	40%	42%	49%

Source: Motor Fan.

Still we expect the development of autonomous vehicles to accelerate

The entry of non-automakers has turned autonomous driving into a battleground of diverse players. We believe Toyota and General Motors have been cool on the concept of fully autonomous vehicles (Level 4 automation) and are instead focusing on Level 3 (limited self-driving). We believe this is because of the exorbitant amount of time it would take to convert all vehicles to Level 4 and because of the view that safe operation of a vehicle is impossible without driver intervention. Also, it could be difficult to determine if a vehicle was responsible in the event of an accident. Google, on the other hand, is rapidly advancing its development on the basis of full self-driving automation by 2017. In any case, most companies expect the era of self-driving will arrive in 2020-2025 and the repercussions for the industry and society are widespread. Already a shrinking percentage of young people are getting driver’s licenses in developed countries such as the US and UK. If autonomous driving and car sharing take hold in urban areas, young people in those areas may never learn how to drive, much as the introduction of automatic transmissions created a population unfamiliar with operating a stick shift.

Exhibit 24: Google plans to be the first company to achieve Level 4 automation
Autonomous driving roadmap



2017 Google to launch autonomous driving
Cadillac to launch high-speed autonomous driving
～2020 Daimler to launch urban/high-speed autonomous driving
Nissan to launch autonomous driving
2020～ Bosch to launch highway autonomous driving
Toyota to launch semi-autonomous driving

～2025 Continental to launch autonomous driving in steps

*No disclosure from VW and BMW

Source: Company interview, Goldman Sachs Global Investment Research.

Saving lives by reducing road accidents

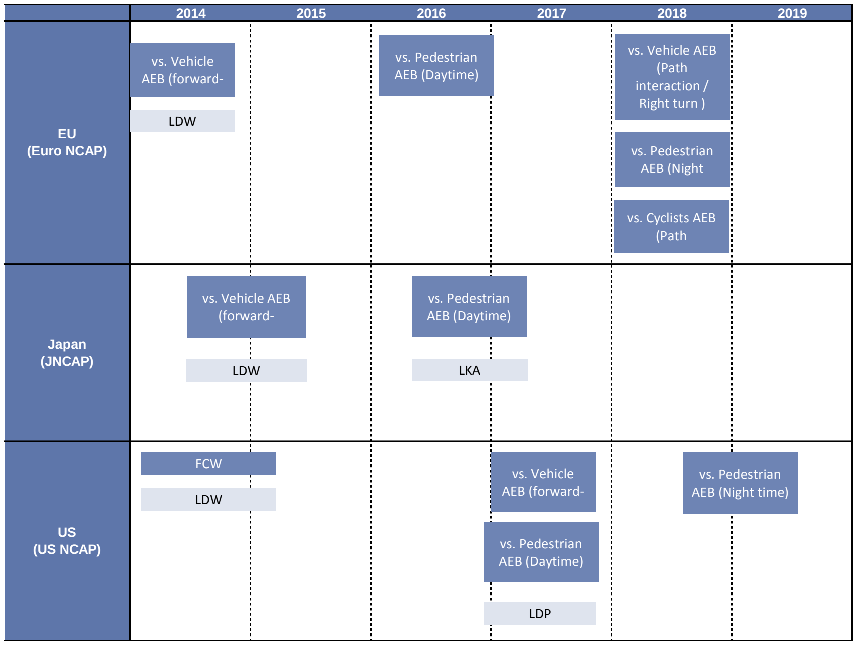
Official statistics show that around 500,000 people die from road accidents every year, but some data suggest annual fatalities are more than 1.2 mn. In the United States and Japan, where car ownership is high, the number of injuries from road accidents is also high, but the percentage of fatalities is lower than in other countries. We attribute this to advances in medical technology and improvements in vehicle safety features such as airbags and ABS. In emerging markets like China and India, where car ownership is likely to increase substantially, reducing the number of road accidents looks set to be a major challenge.

Total accident prevention via full automation is unrealistic

Road accidents would no longer be a concern if all vehicles were fully automated (Level 4), but achieving this on a global scale would take an extremely long time. In the meantime, automakers are faced with the urgent task of using existing devices, such as sensors, cameras, and radar, to develop affordable preventive safety features. We expect the proportion of vehicles with advanced driver assistance systems (ADAS) to increase in Europe to 60% in 2018 from 10% in 2013, and in the US to more than 20% from less than 10% over the same period. In Asia, we expect the proportion to increase to nearly 10% from nearly 5%, with Japan accounting for much of the increase.

Exhibit 25: ADAS is a determining factor of a vehicle's reputation

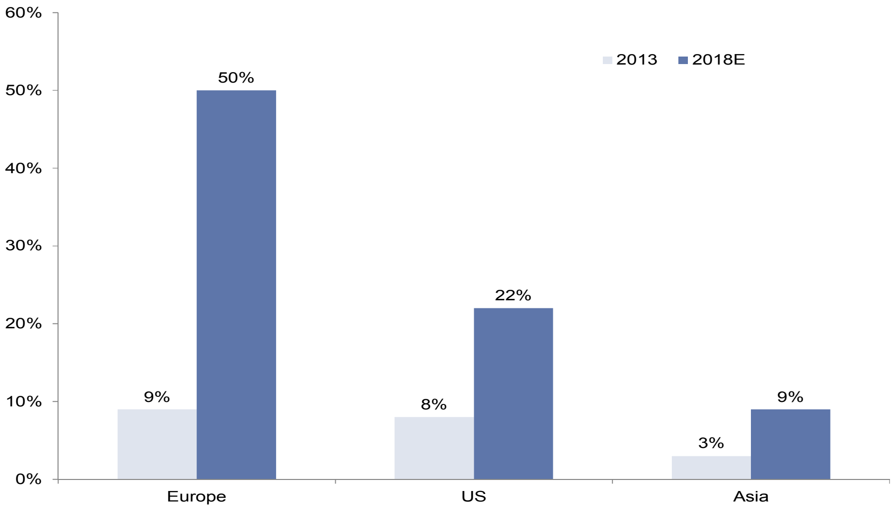
NCAP evaluation criteria


2014
2015
2016
2017
2018
2019
EU
(Euro NCAP)
vs. Vehicle AEB (forward-
LDW
vs. Pedestrian AEB (Daytime)
vs. Vehicle AEB (Path interaction / Right turn)
vs. Pedestrian AEB (Night
vs. Cyclists AEB (Path
Japan
(JNCAP)
vs. Vehicle AEB (forward-
LDW
vs. Pedestrian AEB (Daytime)
LKA
US
(US NCAP)
FCW
LDW
vs. Vehicle AEB (forward-
vs. Pedestrian AEB (Daytime)
LDP
vs. Pedestrian AEB (Night time)

Source: Company data.

Exhibit 26: ADAS market penetration has been rapid

ADAS adoption by region



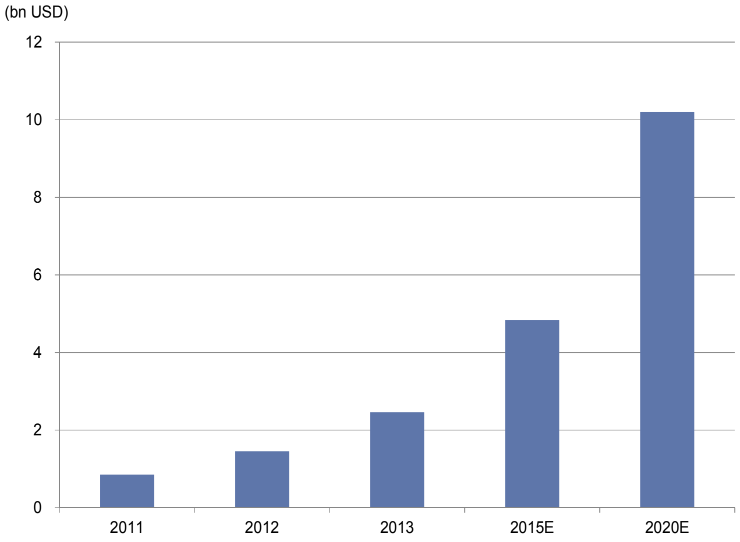
Source: Company data, Goldman Sachs Global Investment Research.

Sensor market to grow to $10 bn by 2020; demand for image recognition growing also

We expect ADAS, mainly automatic braking, to become an increasingly important feature in automotive safety evaluation from 2016, and expect 2016 to mark the start of a period of rapid growth in shipments of ADAS products. We forecast that the market for core ADAS features, which includes millimeter wave radar, cameras, laser radar, and ultrasonic sensors, to grow to US$10 bn in 2020 from US$2 bn in 2013. The total market is set to be several times larger if we include components such as connectors, ECUs, and actuators. The growth potential for companies that make electronic components in these fields is therefore substantial.

Exhibit 27: Sensor market to grow rapidly

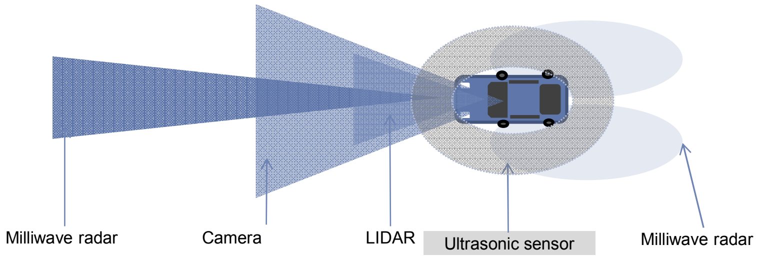
Estimated size of the sensor market



Source: Goldman Sachs Global Investment Research.

Exhibit 28: ADAS incorporates several types of technology

Technological devices behind ADAS



Sensors	Camera	Milliwave radar			LIDAR	Ultrasonic	Infrared
		76/77GHz	79GHz	24GHz			
Warning range							
Short ～ 2m	○	×	×	○	△	◎	○
～ 20m	○	×	×	○	×	○	○
Middle ～ 40m	○	○	○	△	○	×	○
Long ～ 150m	○	○	△	×	○	×	○
Range resolution (～30cm)	×	×	○	○	○	×	×
Angle detection range	○	×	○	○	×	△	○
Relative velocity detection	×	○	○	○	×	×	×
Usage environment							
Rain/Snow/Fog/Thunder	×	○	○	○	×	○	○
High temperature	○	○	○	○	○	○	×
In the dark	×	○	○	○	○	○	○

Source: Company data, Nikkei BP, Goldman Sachs Global Investment Research.

Exhibit 29: Stocks in focus

Autonomous driving

Company	Ticker	Region	Market Cap. (US$, mn)	Comment
Autonomous				
ADAS				
Mobileye	MBLY	Netherland	10,250	Mobileye is a technological leader in the area of software algorithms, system-on-chip
Denso	6902.T	Japan	45,954	Global No.1 revenue auto parts maker. Toyota has 22% stake.
Continental	CONG.DE	Germany	48,131	High tech auto parts maker. It has high end tire business as well.
Delphi	DLPH	US	25,126	High tech auto parts maker.
Valeo	VLOF.PA	France	13,381	Global automotive suplier. Partnership with Mobileye on mono/stereo and Lidar solutions.
Autoliv	ALV	Sweden/US	11,478	Global automotive suplier. They are developing ADAS systems on its own and targets revenues of c.$1bn by 2019.
ON Semiconductor	ON	US	5,434	Major semiconductor maker; Strong in image sensors and analog content.
Nidec	6594.T	Japan	21,905	World No.1 small precision motor maker. Aiming to expand Tier 1 business with ADAS producs through M&A.
Nippon Ceramic	6929.T	Japan	381	World No.1 ultrasonic sensor maker for automated drive / auto parking
IRISO Electronics	6908.T	Japan	863	Top tier connector maker for cameras and sensors. Long history in infotainment business.
Sensors and cameras				
Hitachi	6501.T	Japan	33,828	Hitachi's sub. Called Hitachi Automotive Technology. Global Top 10 revenue in auto parts business.
Toshiba	6502.T	Japan	14,340	Integrated Elec. Maker. Strong in camera and sensors.
Sony	6758.T	Japan	37,006	Cosumer Electric maker. Strong in camera and sensors.
Panasonic	6752.T	Japan	36,316	Cosumer Electric maker. Strong in camera, sensors and Li-ion battery. Has a close relationship with Tesla.
Freescale	FSL	US	13,315	Major semiconductor maker. Strong in analog and MCU.
Texas Instruments	TXN	US	57,600	Major semiconductor maker. Strong in analog and MCU.
Infinion	IFX.DE	Germany	14,536	Major semiconductor maker. Strong in logic and memory.
Delphi	DLPH	US	25,126	High tech auto parts maker.
Valeo	VLOF.PA	France	13,381	Global automotive suplier. Partnership with Mobileye on mono/stereo and Lidar solutions.
Autoliv	ALV	Sweden/US	11,478	Global automotive suplier. They are developing ADAS systems on its own and targets revenues of c.$1bn by 2019.
NXP	NXPI	US	26,981	Leading auto connectivity semis.
Analog Devices	ADI	US	21,037	Supplier of automotive sensors for safety.
TE Connectivity	TEL	US	28,445	Leader in connectors and sensors for auto.

Source: Datastream, Goldman Sachs Global Investment Research.

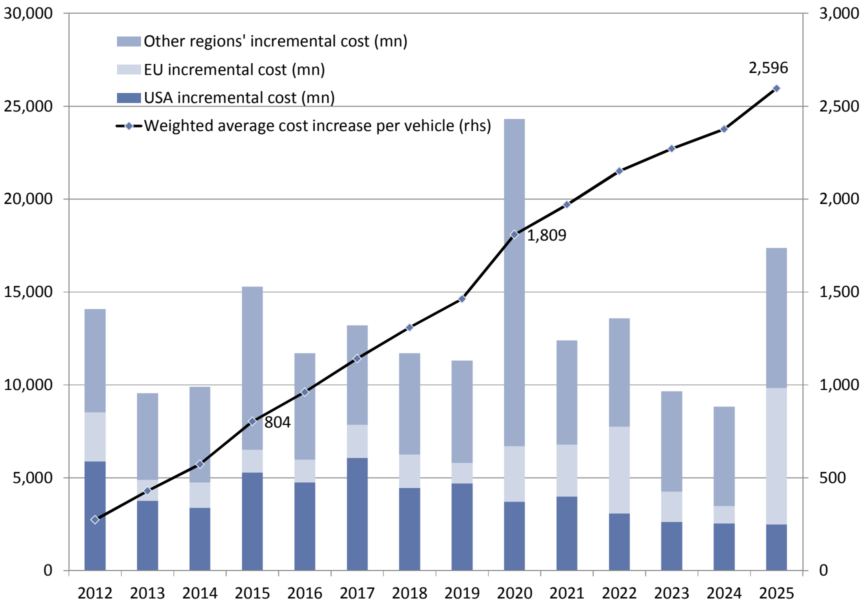
4. Power shift to mega suppliers: Can offer advanced tech

Higher automaker cost burden may present business opportunities for high-tech parts makers

We expect fuel economy regulations to be tightened in 2020-2025 in the major markets of Japan, the United States, Europe, and China. We estimate the cost increase necessary to meet regulations in each country to reach more than US$2,500 per vehicle through 2025, equating to US$25 bn in total. We see these costs peaking in 2020 and 2025. Many automakers are looking to cut costs by US$500-US$1,000 per vehicle via platform sharing and parts standardization, but this may not be enough, in our view. We believe parts makers with strengths in fuel economy technologies are well positioned to benefit from new sales and business opportunities.

Exhibit 30: Spending on lowering CO2 emissions is rising

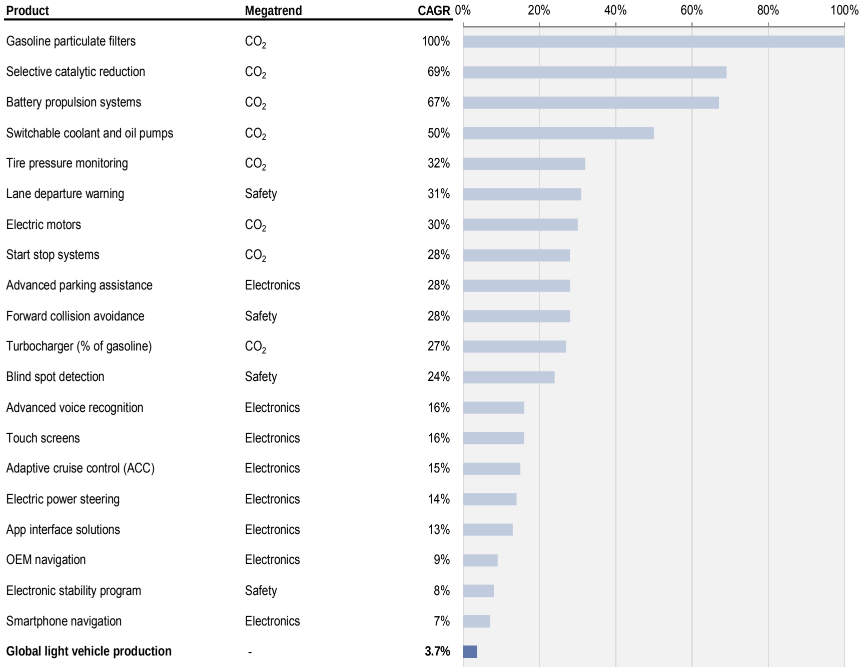
Simulation of cost increases needed to cut CO2 (USD)



Source: IHS, company interviews, Goldman Sachs Global Investment Research.

Exhibit 31: Fastest-growing automotive technologies are in emission control

Expected market CAGR by supplier product area (2012-2020)



Product	Megatrend	CAGR
Gasoline particulate filters	CO_2	100%
Selective catalytic reduction	CO_2	69%
Battery propulsion systems	CO_2	67%
Switchable coolant and oil pumps	CO_2	50%
Tire pressure monitoring	CO_2	32%
Lane departure warning	Safety	31%
Electric motors	CO_2	30%
Start stop systems	CO_2	28%
Advanced parking assistance	Electronics	28%
Forward collision avoidance	Safety	28%
Turbocharger (% of gasoline)	CO_2	27%
Blind spot detection	Safety	24%
Advanced voice recognition	Electronics	16%
Touch screens	Electronics	16%
Adaptive cruise control (ACC)	Electronics	15%
Electric power steering	Electronics	14%
App interface solutions	Electronics	13%
OEM navigation	Electronics	9%
Electronic stability program	Safety	8%
Smartphone navigation	Electronics	7%
Global light vehicle production	-	**3.7%**

Source: IHS, company interviews, Goldman Sachs Global Investment Research.

High-tech parts makers positioned well in our CP framework

Based on our GS Competitive Positioning (CP) framework for global autos (see *Global: Automobiles: Upward mobility: The rise of global autos*, published May 1, 2014), we view the technology-parts suppliers segment as being strongly positioned, primarily driven by its attractive growth profile. The key growth drivers include: (1) rising 'supplied' content per vehicle, (2) market share gains for the globalized suppliers, and (3) a shift in value-add innovative content towards suppliers. Based on our CP analysis, we concluded that technology parts makers will be able to enjoy sustainably higher mid-term CROCI.

Exhibit 32: BorgWarner, Delphi, Conti and Denso lead technology parts
Suppliers by exposure to technology parts end market

Company	Competitive Positioning												
	Growth score				Structural score							CP score	
	Geographic growth	Segment growth	Region and segment growth	Score	Industry con- centration	Power over suppliers	Power over buyers	Degree of substitution	Barriers to entry	Overall supply side factors	Score	Score	%ile
BorgWarner	2.9%	6.9%	9.8%	4.1	9.0	7.0	10.0	2.0	5.0	6.6	4.7	4.4	92%
Delphi	3.0%	7.1%	10.1%	4.1	8.4	7.1	9.6	1.9	4.6	6.3	4.5	4.3	91%
Continental	3.0%	4.0%	6.9%	3.6	6.6	5.1	8.7	5.0	4.2	5.9	4.2	3.9	86%
Denso	1.8%	2.4%	4.2%	2.7	7.1	7.3	8.7	1.7	3.7	5.7	4.0	3.3	67%
Hella	3.2%	4.8%	8.1%	3.8	5.9	7.1	7.5	2.3	3.5	5.3	2.7	3.2	61%
Keihin	2.8%	4.2%	7.0%	3.6	6.1	7.5	8.0	1.5	3.0	5.2	2.6	3.1	58%
TRW Automotive	3.1%	4.1%	7.2%	3.7	5.5	7.6	7.7	1.4	2.7	5.0	2.4	3.1	56%
Johnson Controls	2.7%	3.2%	5.9%	3.3	6.0	7.5	8.0	1.5	3.0	5.2	2.6	2.9	52%
Huayu Automotive	6.8%	4.7%	11.5%	4.7	3.0	8.0	6.0	1.0	1.0	3.8	1.2	2.9	51%
Hyundai Mobis	4.0%	3.3%	7.4%	3.7	4.2	7.8	6.8	1.2	1.8	4.4	2.0	2.9	46%
Autoliv	2.9%	3.6%	6.5%	3.4	5.4	7.6	7.6	1.4	2.6	4.9	2.3	2.9	44%
Valeo	3.2%	3.6%	6.7%	3.5	4.8	7.7	7.2	1.3	2.2	4.6	2.2	2.8	42%
Tenneco	3.0%	3.5%	6.5%	3.4	5.4	7.6	7.6	1.4	2.6	4.9	2.3	2.8	39%
Aisin Seiki	1.5%	2.3%	3.9%	2.3	6.5	7.4	8.2	1.7	3.4	5.4	3.4	2.8	39%
GKN	2.7%	2.7%	5.4%	3.1	5.4	7.6	7.6	1.4	2.6	4.9	2.3	2.7	33%
Lear	3.0%	2.4%	5.4%	3.2	4.4	7.8	7.0	1.2	2.0	4.5	2.1	2.6	31%
Minth Group	5.6%	3.4%	9.0%	3.9	3.0	8.0	6.0	1.0	1.0	3.8	1.2	2.5	30%
Stanley Electric	2.7%	1.5%	4.1%	2.5	3.6	7.4	5.9	2.1	2.1	4.2	2.0	2.2	22%
Magna	2.5%	1.5%	4.0%	2.5	4.2	7.8	6.8	1.2	1.8	4.4	2.0	2.3	24%
Faurecia	2.6%	1.3%	3.9%	2.4	4.2	7.8	6.8	1.2	1.8	4.4	2.0	2.2	20%
TS Tech	3.0%	1.2%	4.2%	2.7	3.0	8.0	6.0	1.0	1.0	3.8	1.5	2.1	19%
Hyundai Wia	3.8%	0.7%	4.5%	2.9	3.0	8.0	6.0	1.0	1.0	3.8	1.2	2.0	16%
Dana	2.5%	1.3%	3.9%	2.2	3.8	7.9	6.6	1.1	1.6	4.2	1.5	1.9	10%
Meritor	2.6%	0.6%	3.2%	1.7	3.0	8.0	6.0	1.0	1.0	3.8	1.2	1.4	6%
Calsonic Kansei	2.3%	0.8%	3.0%	1.6	3.0	8.0	6.0	1.0	1.0	3.8	1.2	1.4	5%
Tower Int'l	2.4%	0.4%	2.9%	1.6	3.0	8.0	6.0	1.0	1.0	3.8	1.2	1.4	3%
Toyota Boshoku	1.9%	0.6%	2.5%	1.2	3.0	8.0	6.0	1.0	1.0	3.8	1.2	1.2	1%
Unipres	1.9%	0.3%	2.2%	1.1	3.0	8.0	6.0	1.0	1.0	3.8	1.2	1.1	0%

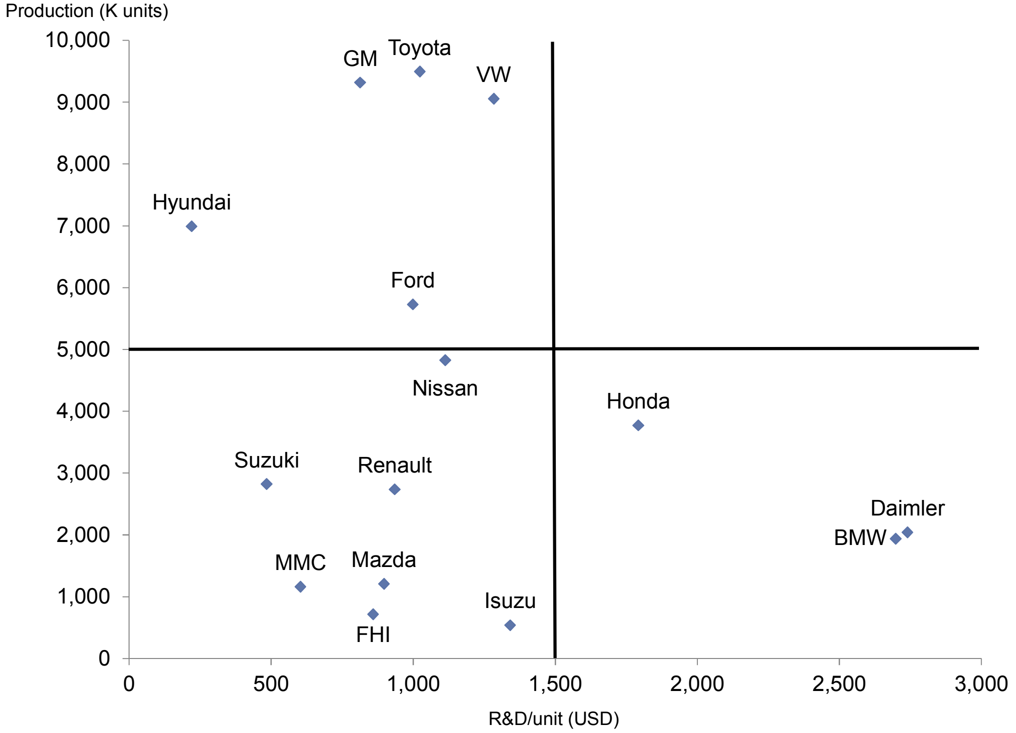
Source: IHS, company interviews, Goldman Sachs Global Investment Research

Economies of scale needed for OEMs, but not the be-all and end-all

One way for a company to minimize risks involved in running an auto business amid a rapidly changing market environment is to diversify investments across all of its technologies with a sufficient R&D budget. This makes sense economically for automakers with annual sales volume of more than 10 mn vehicles, such as Toyota and Volkswagen, but it by no means leaves other automakers out in the cold. History shows how a single technology can often lead to major success for a company: Ford's bold shift to an aluminum body-in-white, Mazda's realization of SKYACTIV technology through concentrated investment in internal-combustion engines, and Tesla's establishment of a business model specializing in EVs. We see potential opportunities for investment from analyzing each automaker's core technologies rather than paying too much attention to absolute levels of R&D spending. A growing number of automakers seek to surmount economies of scale through alliances in certain areas. In our view, it is not all about being large; the smaller players also have a chance to excel.

Exhibit 33: Scale matters for OEMs

R&D per vehicle

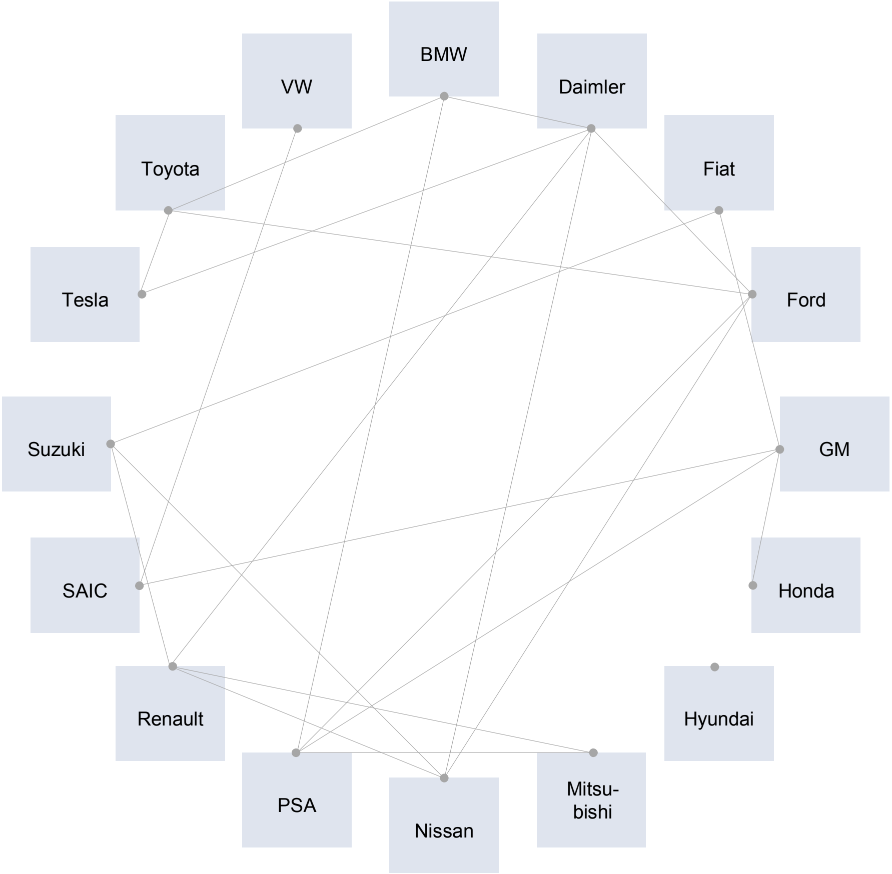


Source: Company data, Goldman Sachs Global Investment Research.

Expecting partial alliances to become common practice among OEMs

We expect the unprecedented pace of technological advancement to put pressure on automakers to clearly identify their priorities. Partial technological alliances are likely to increase across manufacturers, with the exception of Toyota, GM and Volkswagen, which steadily generate annual sales of around 10 mn vehicles. We believe Toyota is the only profitable hybrid vehicle manufacturer at the moment, with annual production of 1.2 mn-1.3 mn vehicles. The increase in R&D investment per vehicle over the past three years as a proportion of sales volume is US$1,023 at Toyota and US$1,283 at Volkswagen, versus US$1,113 at Nissan, US$1,793 at Honda, US$814 at General Motors, and US$999 at Ford. We believe few automakers have the capacity to achieve engine innovation (direct injection, turbo, HCCI) alongside rapid and comprehensive development of plug-in hybrids, EVs, and FCVs.

Exhibit 34: Alliance to become common practice
Partnerships and alliances



Source: Company data, Goldman Sachs Global Investment Research.

Exhibit 35: Stocks in focus

Mega suppliers

Company	Ticker	Region	Market Cap. (US$, mn)	Comment
Mega Suppliers				
Denso	6902.T	Japan	45,954	Global No.1 revenue auto parts makers. Toyota has 22% stake.
Continental	CONG.DE	Japan	48,131	High tech auto parts maker. It has high end tire business as well.
Delphi	DLPH	US	25,126	High tech auto parts maker.
Magna	MGA	Canada	23,747	High tech auto parts maker.
Aisin	7259.T	Japan	13,151	World top 3 automatic transmission maker. Toyota has 22% stake.
Bosch	Non-listed	Germany	-	Global No.2 revenue auto parts maker.
ZF	Non-listed	Germany	-	World top 3 automatic transmission maker.

Source: Datastream, Goldman Sachs Global Investment Research.

5. New entrants afoot: Firms like Google, Apple could join fray

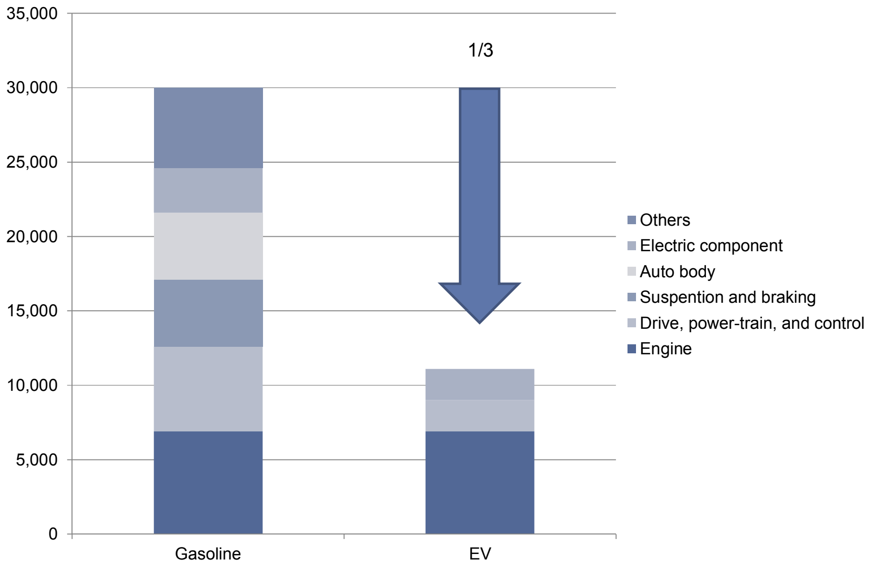
Autonomous driving, electric vehicles bring prospect of new industry entrants

The potential of autonomous driving and electric vehicles to change the nature of cars brings with it an opportunity for new entrants in the industry. As we have discussed, Google has said that it wants to realize full Level 4 automation by 2017. Various media have reported that Apple plans to enter the auto industry. Both companies are armed with immense technological capabilities and cash piles to make large investments in new platforms. And Tesla has rapidly made inroads with its electric vehicles. All of these new competitors threaten the profit centers of existing automakers.

EVs have only one-third as many parts as gasoline-powered vehicles

The pace of EV penetration is well below the pace forecast by Nissan and other automakers five years ago. This reflects obstacles like battery costs and durability, and limited charge times. However, one structural advantage of EVs is that they have fewer parts. Also, business expansion by Tesla, Apple, and other new entrants is likely to spur advances in EV technology. Research to double the energy density of lithium ion batteries by 2017-2018 is advancing according to AESC, MMC and other battery makers, and we expect further innovation. Public recognition surveys in Japan show that EVs are the most well-known type of eco-car (compared with clean diesel vehicles, PHEVs, and FCVs).

Exhibit 36: EVs have one-third as many parts as conventional vehicles
Comparison of parts numbers for gasoline cars and EVs



Source: METI, company interview, Goldman Sachs Global Investment Research.

Will Apple's iCar become a reality?

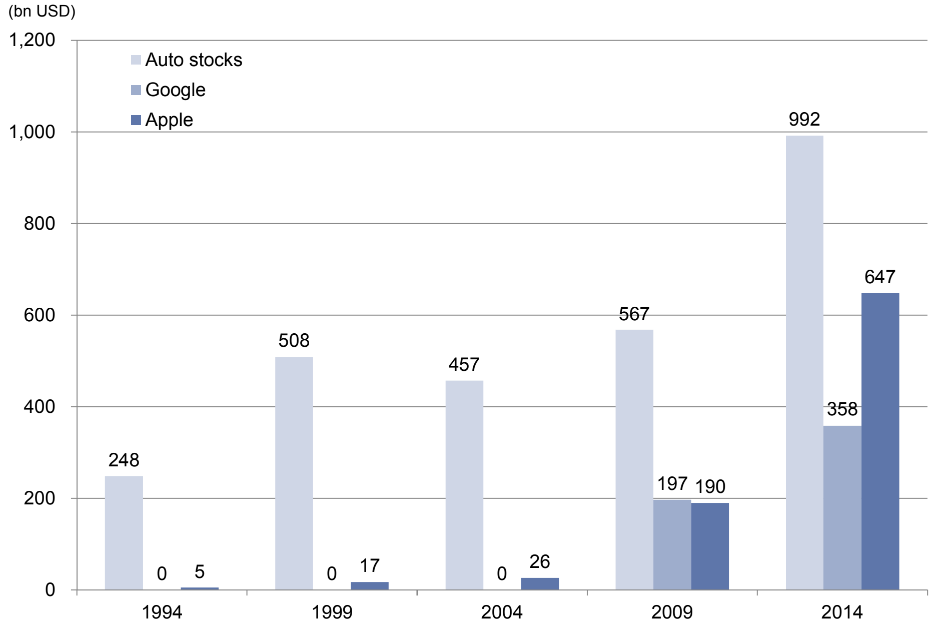
Various media have reported that Apple plans to enter the auto industry. For example, Bloomberg reported on February 20, 2015 that Apple wants to begin vehicle production as early as 2020, but at this time no overall picture has emerged. Our technology hardware analyst Bill Shope believes it is still unclear whether Apple intends a full-fledged entry into auto production, and autos are just one of several new business projects it is considering. However, we see potential for Apple to leverage its strengths in areas such as electric vehicles, autonomous driving, and in-car apps. We see a need to assess Apple's ability to roll out an auto business from various perspectives: for example, will it make vehicles itself, will it focus on the high-end market to start with, and could it team up with established auto makers to sell vehicles?

No. 2 Motor cycle maker, Yamaha to enter automotive business in 2019

High-tech firms are not alone in eyeing a move into the auto business. Yamaha Motor, the world's no. 2 motorcycle maker, has expressed its intention to produce autos as a new source of growth. It has yet to disclose any detailed plans, but several media outlets, including the Nikkei, have reported that the company is looking to launch a minicar in 2019, primarily in Europe. The Nikkei said that Yamaha Motor may also seek to establish a production base. With the company having showcased a two-seater concept car (gasoline and electric) at the Tokyo Motor Show in 2013, we believe it is keen to get into the market.

Exhibit 37: Apple and Google's market cap (Top 500)

Total auto industry market cap vs. Google and Apple



Source: Bloomberg.

New comer, Tesla slated to begin operation of its gigafactory from 2017

While battery technology to realize vehicle electrification is developing on a daily basis, we expect the outcome of Tesla’s gigafactory initiative (a total investment of US$5 bn) to be a significant turning point over the next 5-10 years. Japanese household appliance maker Panasonic has said it expects to invest 30%-40% of the factory’s production equipment. The plant’s production capacity is expected to be 50GWh by 2020, equivalent to the capacity of 3.5 standard nuclear power plants. With 35GWh, the company plans to produce 500,000 Tesla vehicles. 15GWh is used for home battery production. Tesla and Panasonic believe they can reduce battery cost by about 30%-40% through full-fledged operation of the new plant.

We expect the price per watt-hour to halve in the next 10 years

The Japanese government projects that by around 2020 EVs with a driving range of 250-300 km will be in popular demand and the price per watt-hour (Wh) will have fallen to around US$0.50. We believe the Japanese government’s projections carry some weight given the number of battery-related suppliers in Japan. However, if Tesla can achieve the cost savings described above, we believe the government’s cost projection could be achieved three to five years earlier. Based on the same battery roadmap, however, we would not expect the cost of EVs to fall dramatically in 2020-2030. Manufacturers are expected to increase battery capacity in order to lengthen an EV’s driving range, so based on the roadmap it would not be until 2030 onwards that EVs reach the mass market price range (¥2 mn or less; driving range 500 km).

Exhibit 38: EVs should become affordable by the late 2020s

Battery roadmap

	Current	2020	2030	2030〜
Travel distance :	120 〜 200 km	250 〜 300 km	around 500 km	around 700 km
Battery weight :	200 〜 300 kg	100 〜 140 kg	80 kg	80 kg
Battery pack capacity :	16 〜 24 kWh	25 〜 35 kWh	40 kWh	56 kWh
Battery cost, vehicle cost :	¥1.1mn 〜 2.4mn, ¥2.6mn〜3.76mn	¥0.5mn 〜 0.8mn, ¥2mn〜2.3mn	¥0.4mn, ¥1.9mn	¥0.28mn, ¥1.8mn

Source: NEDO.

Exhibit 39: Stocks in focus

New entrants

Company	Ticker	Region	Market Cap. (US$, mn)	Comment
New Entrants				
Tesla	TSLA	US	31,314	High end EV makers. Aiming to become world biggest Li-ion makers by 2020.
Google	GOOGL	US	159,848	Internet company. Targeting level 4 autonomous driving in 2017.
Apple	AAPL	US	763,566	Ecel. hard wear company. Reportedly interested in automobile business entrance.
Yamaha	7272.T	Japan	8,487	World No.2 motorcycle maker. Targeting car business in 2019.
Battery pack				
Panasonic	6752.T	Japan	36,316	Cosumer Electric maker. Strong in camera, sensors and Li-ion battery. Has a close relationship with Tesla.
Tesla	TSLA	US	31,314	High end EV makers. Aiming to become world biggest Li-ion makers by 2020.
GS Yuasa	6674.T	Japan	1,852	Japanese Li-ion battery maker. Has JVs with both Honda and Mitsubishi Motors.
LG Chem	051910.KS	Korea	16,353	One of the largest Li-ion battery manufacture
AESC	Non-listed	Japan	-	One of the largest Li-ion battery manufacture. Nissan and NEC have majority of stakes.
Cathode material				
Nichia	Non-listed	Japan	-	Global No.1 in market share in Cathode material. Also famous for LED.
Umicore	UMI	Belgium	5,583	Global top 3 in market share
Toda Kogyo	4100.T	Japan	188	Global top 5 in market share
Nippon Chemical Industrial	4092.T	Belgium	189	Global top 5 in market share
Tanaka Chemical Corp.	4080.T	Japan	60	Global top 5 in market share
Mitsubishi Chemical	4188.T	Japan	9,671	Global top 5 in market share
Anode material				
Hitachi Chemical	4217.T	Japan	4,191	Global No.1 in market share (30%)
Mitsubishi Chemical	4188.T	Japan	9,671	Global No.3 in market share
Tokai Carbon	5301.T	Japan	670	Global No.5 in market share
Nippon Carbon	5302.T	Japan	367	Global No.5 in market share
Showa Denko	4004.T	Japan	2,083	Global No.5 in market share
Separator				
Asahi Kasei	3407.T	Japan	12,773	Global No.1 in market share (over 30%)
Celgard	Non-listed	Japan	-	Affiliate of Polypore. Global No.3 in market share
Toray	3402.T	Japan	13,729	Global No.3 in market share
Ube Industries	4208.T	Japan	1,915	Top tier in market share
Sumitomo Chemical	4005.T	Japan	9,501	Top tier in market share
Mitsui Chemical	4183.T	Japan	3,459	Top tier in market share
Polypore	PPO	US	2,691	Top tier in market share. Asahi Kasei announced to marger Plypore in February 2015.
Electrolyte Solution				
Ube Industries	4208.T	Japan	1,915	Global No.1 in market share (over 20%)
Mitsubishi Chemical	4188.T	Japan	9,671	Top tier in market share
LG Chem	051910.KS	South Korea	16,353	Top tier in market share
Lithium producer				
SQM	SQM	Chile	6,229	Global No.1 lithium producer.
FMC	FMC	US	7,780	Holding FMC Lithium as an affiliate, the top tier lithium producer.

Source: Datastream, Goldman Sachs Global Investment Research.

6. Connected cars and shared mobility: Shifting business models from networked

Connecting cars to networks has implications beyond the auto industry

The networking of cars has implications that extend beyond automakers and technology companies to industries ranging from auto insurers to rental companies, taxis and emerging car-sharing services. The sharing of data from vehicles allows insurers to better monitor behavior and price policies. A reduction in accidents reduces claims. The ability to instantly connect people who need to get somewhere with a ride or a vehicle that is sitting idle raises the potential utilization rate for each vehicle. The repercussions of these changes in the business models around personal mobility are likely to ripple across existing industries and spawn new ones.

Many drivers could be content with car sharing

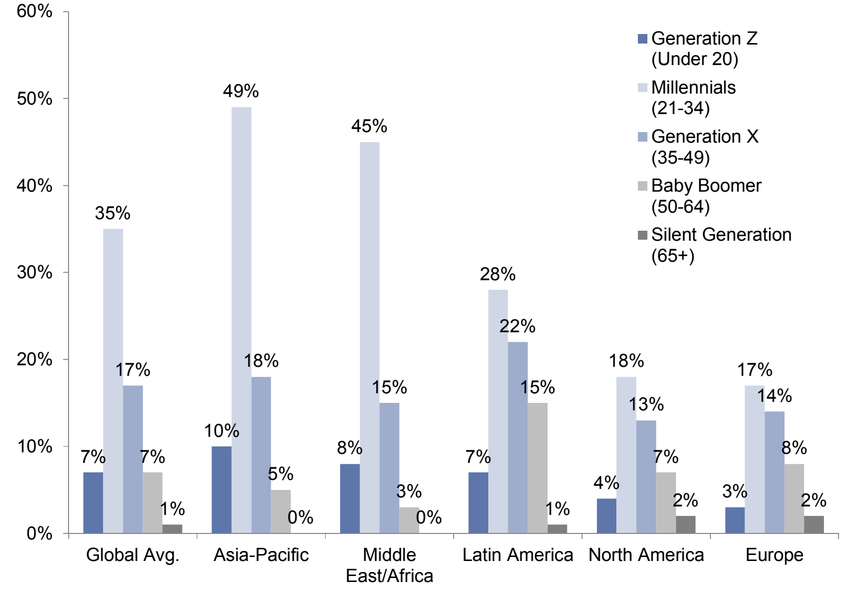
The majority of vehicle owners around the world do not drive at night and even on weekdays they use their vehicles only to commute, leaving their cars in parking lots most of the day and racking up parking fees and insurance premiums. We believe interest in car ownership could diminish in the future. In a 2014 Nielsen survey, almost 35% of 21-34 year olds said they would actively share products or services. Notably, the ratio was high in Asia, Africa, and other emerging market regions.

Cost of owning vehicle has risen

Japanese statistics show that the average vehicle utilization rate is only 3% (we estimate less than 5% on a global basis). If autonomous driving or efficient vehicle sharing were used to increase vehicle utilization rates, this could potentially reduce the number of vehicles. The cost of owning a vehicle has risen sharply in some places recently. In Shanghai, it costs US$12,000 to acquire a license plate, 200 times the cost in California (US$69). If convenient arrangements could be made, we believe an increasing number of drivers would consider car sharing as a cost-effective alternative to ownership.

Exhibit 40: Millennials are willing to share

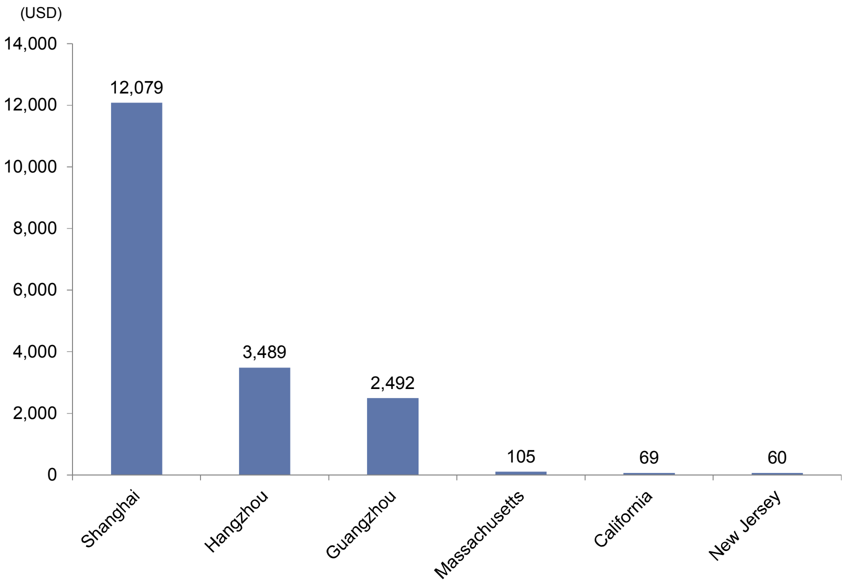
Share community participation willingness by generation



Source: Nielsen.

Exhibit 41: Vehicle ownership costs rising

License plate costs in China and the US

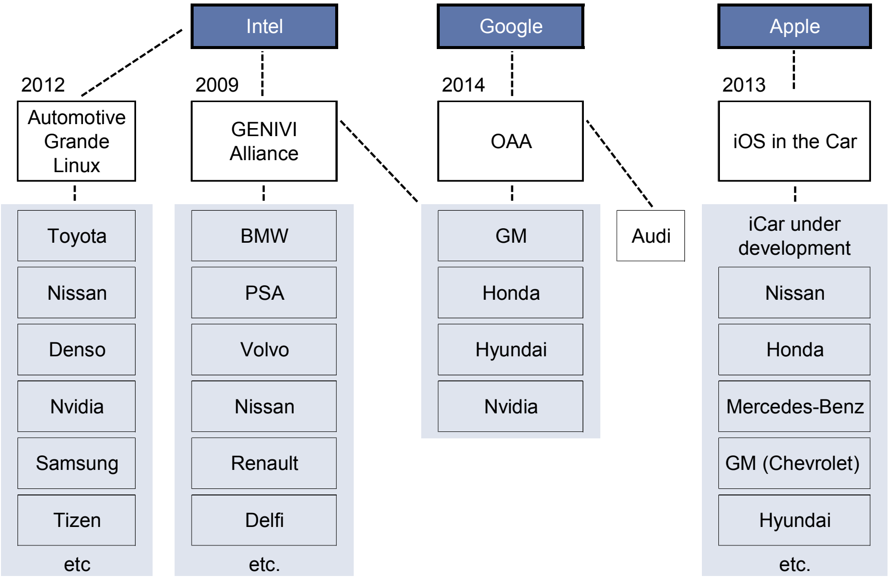


Source: MIIT, China daily, Goldman Sachs Global Investment Research.

Infotainment: How do people really want to pass the time while traveling by car?

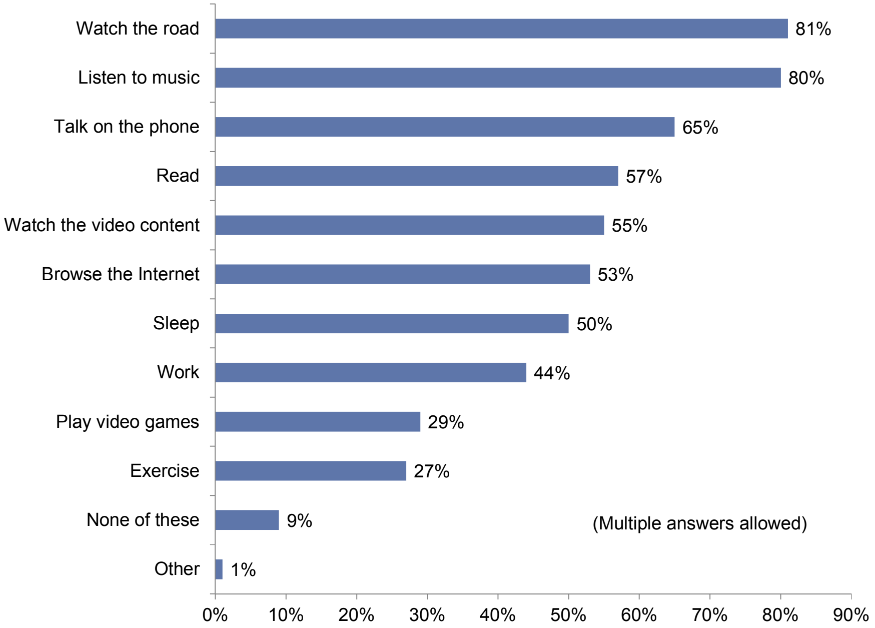
The way in which people pass the time on car journeys is likely to change as connected cars evolve and penetrate the market. In a 2013 survey on CEA Survey, respondents were asked how they would prefer to pass the time while traveling by car. The following activities drew a response rate of over 50%: Watch the road, listen to music, talk on the phone, read, watch video content, browse the internet and sleep. Delivering advances in infotainment is an urgent task for today’s automakers, which have formed alliances with technology firms to enhance the services they offer. Autonomous driving, if realized, would likely hasten the development of infotainment further.

Exhibit 42: Infotainment is driven by three IT giants: Intel, Google, and Apple
Coordination between IT and auto industry over infotainment



Source: IBJ.

Exhibit 43: New service would develop by autonomous driving
Preferred passenger activities in driverless vehicles



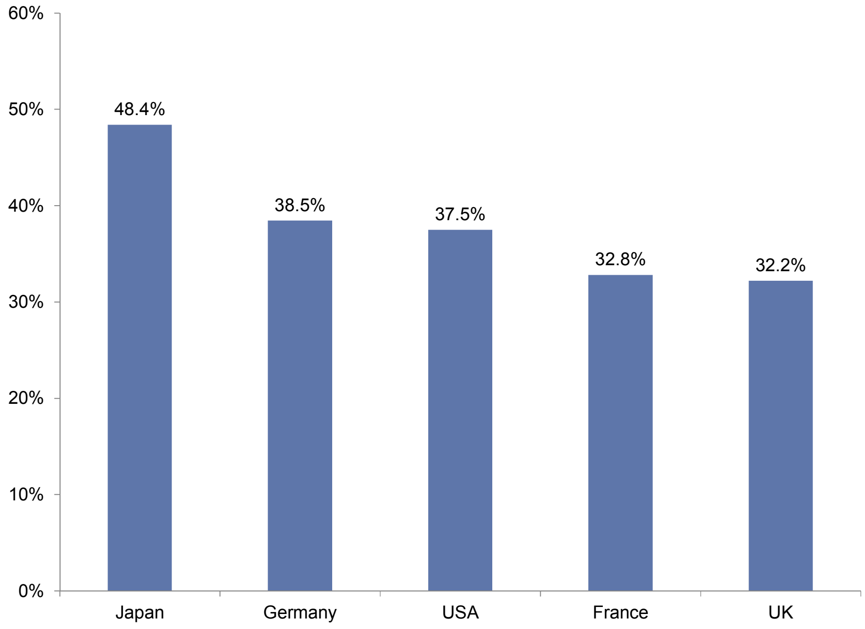
Source: CEA Survey.

Insurance: Confronting changes in business models

Auto insurance premiums are the largest category of insurance in developed markets, and are crucial to insurers' earnings (see Exhibit 44). Telematics, preventive safety, collision avoidance technology and other innovations are positive on the whole for consumers, but for insurers we believe they present both new business opportunities and risks. If there are insurers who are able to analyze driver data more closely as they become more high tech, those players can boost the earnings power by spotting the pockets of value where risk and premium are inappropriately valued. At the same time, however, fewer accidents and a decline in claims over the longer term could reduce premium income per insurance contract (Michael Nannizzi and Taichi Noda).

Exhibit 44: Auto insurance a key earnings source

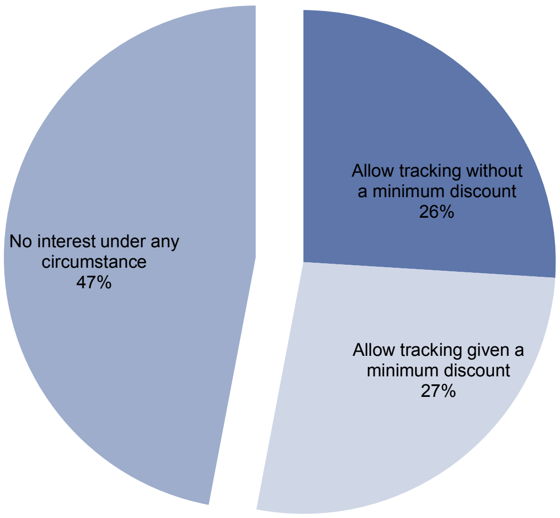
Insurance company earnings breakdown



Source: GIAJ, GDV, SNL Financial, FFSA, ABI, Goldman Sachs Global Investment Research.

Exhibit 45: Driving data could be used to develop new insurance models

Opinion survey on providing driving data



Source: Deloitte, Goldman Sachs Global Investment Research.

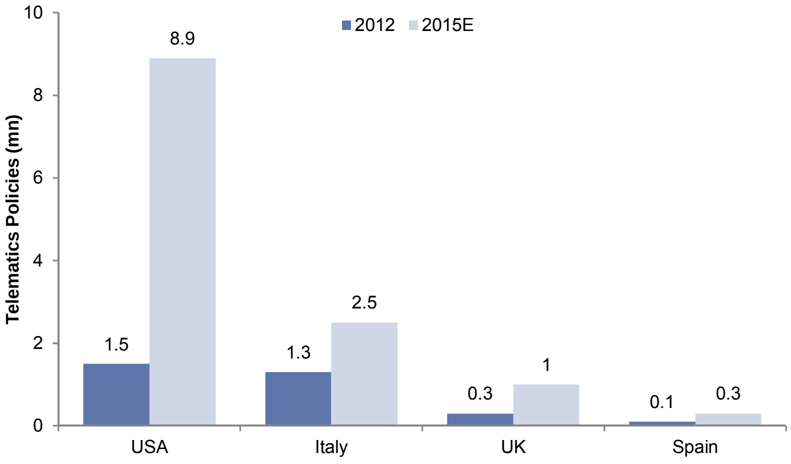
Existing market at risk of contraction due to collision-avoiding cars

Preventive safety and collision avoidance technologies are being introduced in an effort to reduce the frequency of car accidents and the damage they cause. Over the longer term, this is likely to mean lower auto risk. While insurers' margins should improve as better safety technology reduces their insurance payouts over a certain period of time, this improvement will eventually run its course as per-vehicle insurance premium income subsequently declines. This trend is likely to become increasingly evident in a market with: (1) dim prospects for growth in the number of owned vehicles; (2) a short replacement cycle for cars; and (3) schemes introduced to keep margins stable. Meanwhile, we believe accountability for auto accidents will become more complex, and there will be potential new business opportunities for insurers via indemnity insurance products for companies that provide the related infrastructure. However, we need to note that new types of commercial insurance tend to be longer-tailed with fatter tails, which will require new types of insurers that are prepared to take the risk.

Connected cars could alter the competitive landscape for insurers

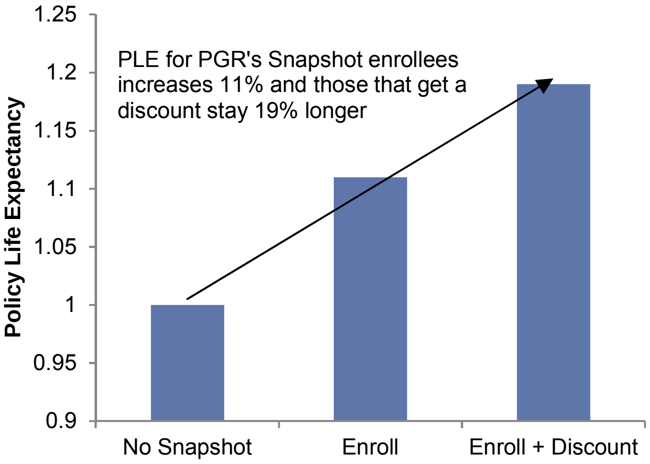
Telematics insurance (usage-based insurance, or UBI) is already beginning to make inroads in the US and European markets. UBI contracts set a premium by drawing on auto tech, smartphones and other devices to measure driving times, locations, and performance. We believe telematics insurance will penetrate at a faster pace over the next 5-10 years and ultimately become the standard for auto insurance. Progressive, the fourth-ranked auto insurance provider in the US, forecasts that UBI products will account for around 25% of auto insurance by 2020, versus 5% today. We expect to see a divide open up between insurers capable of offering attractive premium structures by drawing on data obtained through telematics, and insurers that miss the telematics boat.

Exhibit 46: US, Italy and UK are a growing market for telematics uptake
Telematics policies



Source: Zurich Insurance Group.

Exhibit 47: Auto telematics programs can help boost retention for insurers
Snapshot by Progressive



Source: Progressive.

The role of insurance if fully autonomous cars were to be realized

Many automakers are aiming to develop semi-autonomous cars (Level 3) and assume that drivers will ultimately be responsible for avoiding danger. Google, however, has set its sights on developing Level 4 fully autonomous cars and if realized we believe this will significantly change the role of insurance. Insurance companies have an incentive to sell insurance to drivers as long as there is a possibility of an accident occurring due to driver error, and drivers have an incentive to buy that insurance. However, the incentive to take out personal injury and property damage insurance would disappear with fully automated cars since they are designed to eliminate driver error. Conversely, we would expect more companies to take out product liability insurance. As car insurance will still be needed as a form of property insurance, insurers will still cover drivers for theft, snow damage, and other loss.

Insurance for car sharing and on-demand car services still a gray area in some cases

Car sharing usage fees include insurance, so car sharing companies technically pay insurance to insurers for accidents occurring when cars are not in use. On the other hand, the approach to insurance for on-demand car services such as Uber varies depending on the country. Generally speaking, where a car owner provides unlicensed taxi services, the driver would be covered by a commercial auto insurance policy during operation and covered by the individual's car insurance policy outside of that. However, it is unclear which policy would cover accidents that occur when a driver is searching for customers, and disputes about this sort of case have actually arisen.

Exhibit 48: Stocks in focus

Connected cars

Electrolyte Solution	Ticker	Region	Market Cap. (US$, mn)	Comment
Connected Cars				
Insurance				
MS&AD	8725.T	Japan	19,661	Japanese isurance company. Top 3 share in auto insurance in Japan.
Sompo HD	8630.T	Japan	15,220	Japanese isurance company. Top 3 share in auto insurance in Japan.
Tokio Marine	8766.T	Japan	30,579	Japanese isurance company. Top 3 share in auto insurance in Japan.
ALL	ALL	US	27,649	US insurance company. Top 3 share in auto insurance in USA.
PGR	PGR	US	16,006	US insurance company. Top 3 share in auto insurance in USA.
GEICO	-	US	-	Subsidiary of Berkshire Hathaway. Top 3 share in auto insurance in USA.
Car Sharing				
Orix	8591.T	Japan	20,642	Major Japanese leasing providoer. Focusing on car sharing business in Japan.
Park24	4666.T	Japan	2,752	Japaese parking service provider. Focusing on car sharing business in Japan.
Hertz	HTZ	US	9,637	Major US rent-a-car company.
Uber	Non-listed	US	-	Taxi allocator service provider through internet.
Infotainment				
Intel	INTC	US	158,687	World largest semiconductor maker
Apple	AAPL	US	763,566	Providing car application called CarPlay.
Google	GOOGL	US	159,848	Internet company. Targeting level 4 autonomous driving in 2017.
NVIDIA	NVDA	US	11,223	Major semiconductor maker. Stong in logic and image processing.
Harman	HAR	US	8,883	Major audio equipment maker for automotive, home, theater, etc.
Delphi	DLPH	US	25,126	High tech auto parts maker
Denso	6902.T	Japan	45,954	Global No.1 revenue auto parts makers. Toyota has 22% of stakes.
Continental	CONG.DE	Germany	48,131	High tech auto parts maker. It has high end tire business as well.

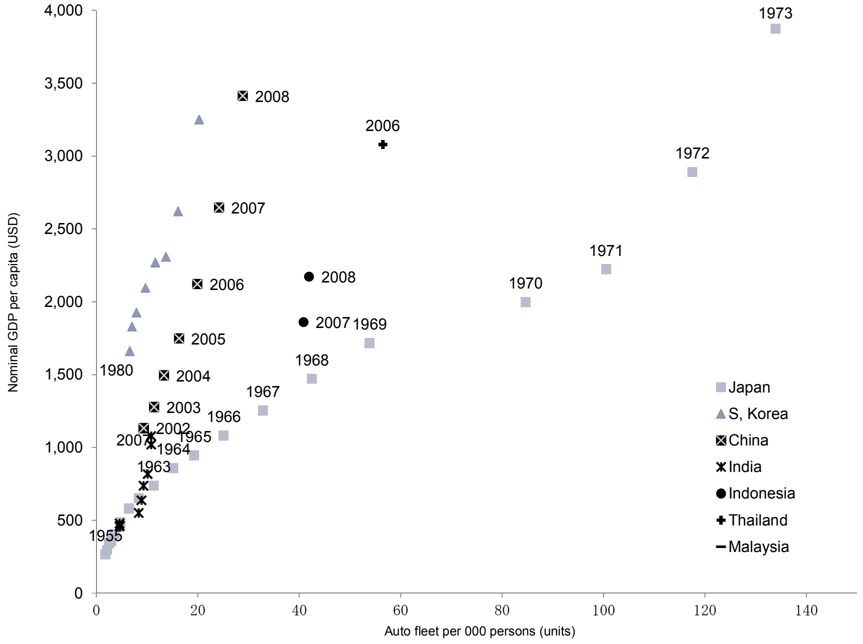
Source: Datastream, Goldman Sachs Global Investment Research.

7. Shift to emerging markets: To spur rise of low-emission vehicles

Motorization in developing nations looks unstoppable

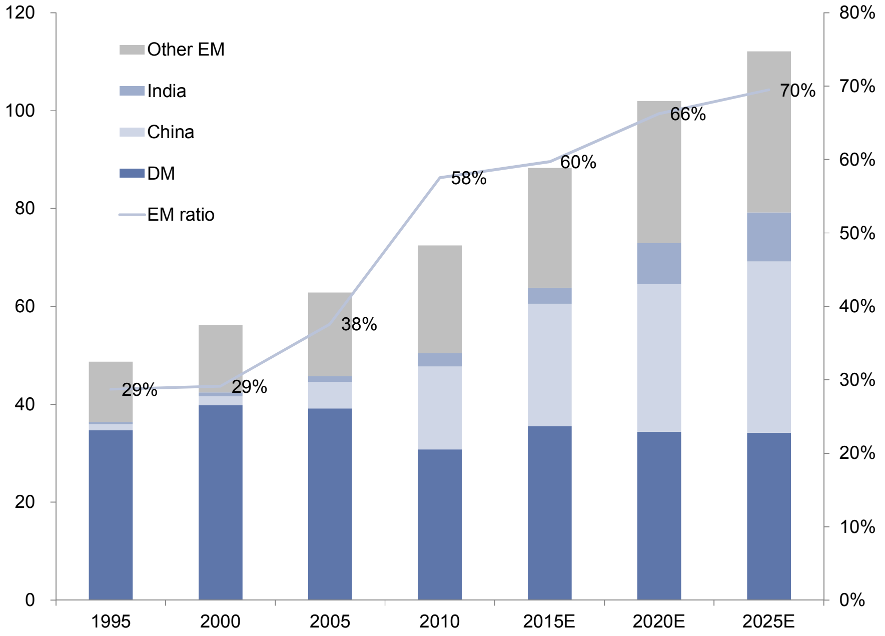
We forecast global auto sales will increase from 80 mn units in 2015 to 100 mn in 2020 and 120 mn in 2025, and we expect developing nations to account for almost all of this growth. We expect per-capita GDP to exceed US$10,000-US$20,000, the level at which motorization generally gains real momentum, in some developing nations around 2025. The importance of low-cost fuel efficiency technologies for developing nations is likely to increase.

Exhibit 49: Motorization looks unstoppable
Per capita GDP



Source: [IHS, Goldman Sachs Global Investment Research.

Exhibit 50: New vehicle sales trending upward
New vehicle sales volume and the developing nation sales ratio



Source: IHS, Goldman Sachs Global Investment Research.

China: Growth expected out to 2025, but rapid pace to ease

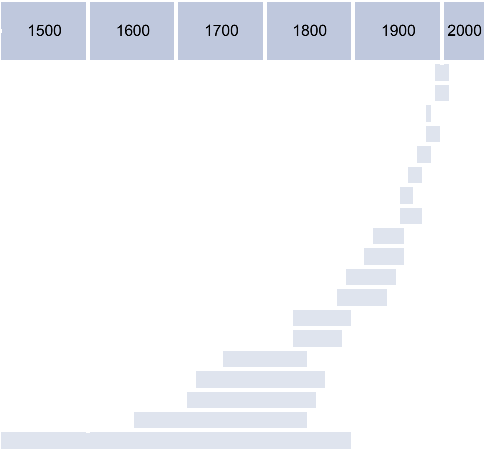
As the car penetration rate in China, the world's largest car market, has exceeded the global average of 12% since 2018E, our China auto analyst Yipeng Yang expects China's new car sales growth to slow. Although we expect China's passenger car market (excluding light commercial vehicles) to expand to around 35mn cars by 2025, we expect the market's CAGR to fall to 5.5% in 2015-2025E from 20% in 2005-2015E, and we forecast China's car penetration rate to increase to 25% by 2025E. In addition, we expect more cities will implement license restrictions and thereby put the brakes on new car sales growth.

- **China car market mix might shift toward non-ICE given stricter CO2 emission rules designed to promote energy security** (China already imports 60% of the petroleum it consumes and autos account for about 60% of petroleum demand). As a result, by 2025E we forecast NEVs to account for 10%-20% of new car sales in China (up from c.5% in 2020E). We also expect the ICE market to move toward smaller engines (with a higher mix equipped with turbo), more efficient fuels like diesel (less CV consumption in future might free up more diesel from car use), micro hybrids (with stop start and regenerative brake) could become compulsory as emission norms become more stringent.
- **We believe car sharing could become more popular in China, especially for city commuters.** As consumers need different cars/solutions for different mobility needs, OEMs will develop more suitable products as well; small cars might be more suitable for daily commuters while SUVs might be more suitable for weekend leisure.
- **Although technologies like autonomous driving do not look feasible in the next ten years** given the technological, legal and infrastructure constraints, we believe ADAS and semi-autonomous driving may become more popular in China.

Exhibit 51: Speed of economic development in individual economies is increasing

Speed of GDP/capital development

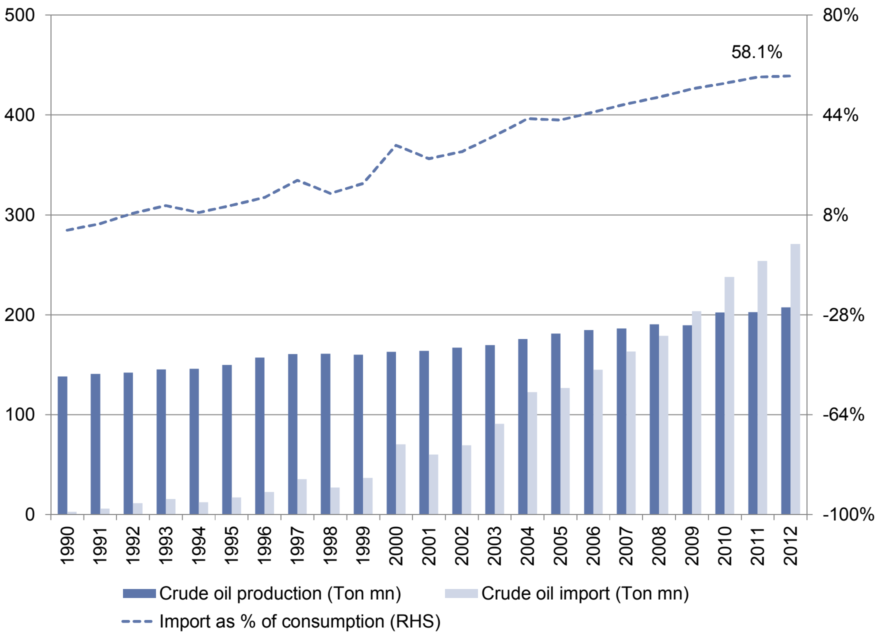
Country	Year real GDP/capita passed:		
	US$1,000	US$2,000	Yrs. taken
Vietnam	1986	2003	17
India	1983	2002	19
China	1979	1991	12
Pakistan	1976	2002	26
Indonesia	1968	1986	18
Thailand	1960	1976	16
Korea	1954	1971	17
Philippines	1950	1975	25
Brazil	1922	1958	36
Malaysia	1917	1969	52
Japan	1892	1950	58
Mexico	1885	1942	57
Argentina	1830	1885	55
Canada	1830	1881	51
USA	1750	1860	110
Germany	1720	1874	154
France	1715	1868	153
UK	1650	1845	195
Italy	1450	1905	455



Source: Company data, Goldman Sachs Global Investment Research.

Exhibit 52: China already imports 60% of the petroleum it consumes

China oil dependency



Source: National Bureau of Statistics of China.

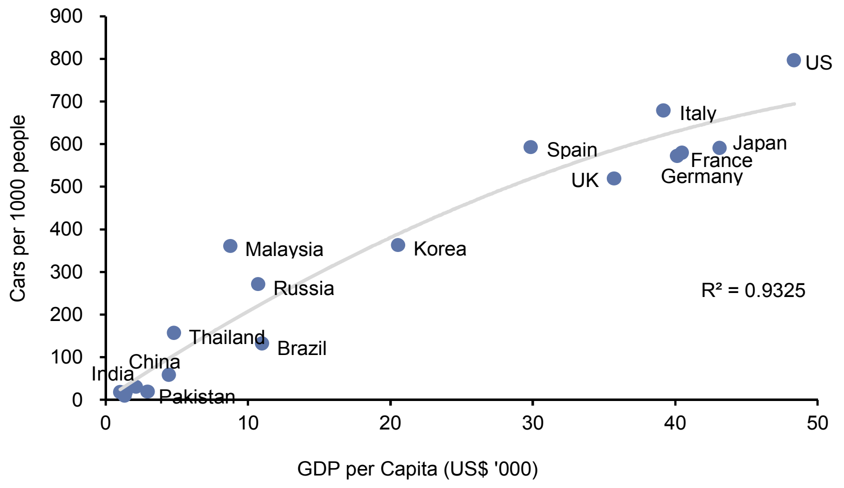
India: Third-largest car market by 2025

India's car market is expected to grow to c.7.4mn by 2025 (as per IHS Global Insight and GS India auto analyst Pramod Kumar) to become the world's third-largest car market spurred by a c.3X jump in per-capita GDP to US$3,500. While US$3,500 per capita GDP looks low compared to global peers, it is a big enough number to drive the car ownership trend given: 1) larger family sizes (average size of five) and the tendency for extended families to live together in India; and 2) cars being looked on family vehicles more than an individual mobility solution. The 2025 forecast assumes an 8.7% volume CAGR in 2014-25E, which is lower than the 11% CAGR in 2003-2014. This is primarily due to infrastructure constraints in cities.

- ➢ **Even as major markets shift toward non-ICE, India is expected to remain largely an ICE market given the cost sensitivity of consumers.** We expect the market to move toward smaller engines (stressed engines), greener fuel like natural gas, and micro hybrids (with stop start) as emission norms become stringent.
- ➢ **Technologies like autonomous driving do not look feasible in the next ten years given the infrastructure constraints.**
- ➢ **Even as the Indian market lags global peers significantly on vehicle technology adoption, consumer attitudes toward car ownership have begun to change in bigger cities** led by youngsters who do not see much merit in owning a car given services like taxi on demand, self-drive car rentals and car-sharing apps.

Exhibit 53: Car penetration globally follows GDP progression

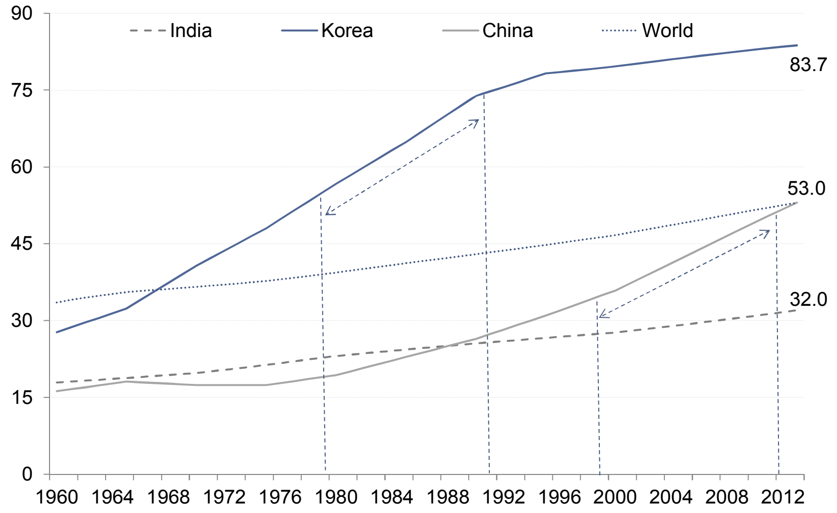
Global car penetration (CY2013)



Source: Automotive Yearbook, Goldman Sachs Global Investment Research.

Exhibit 54: Rate of urbanization

% of urban population



Source: Worldbank

Exhibit 55: Stocks in focus
Shift to EMs

Company	Ticker	Region	Market Cap. (US$, mn)	Comment
Shift to EMs				
China				
Geely	0175.HK	China	4,712	One of the largest pure Chinese local car manufacturer. Relationship with Volvo.
Greatwall	2333.HK	China	6,964	One of the largest pure Chinese local car manufacturer. Strong at SUVs.
BYD	1211.HK	China	6,433	One of the largest EV/PHEV Chinese local manufacturer.
SAIC	600104.SS	China	45,880	Largest Chinese local car manufacture. JV with VW and GM.
India				
Maruti Suzuki	MRTI.BO	India	17,605	Top share car maker in India. It has 40-45% share historically. Suzuki has over 50% stake.
Tata	TAMO.BO	India	23,389	Second largest car maker in India. It aquired Jaguar.
Ola cabs	Non-listed	India	-	Taxi allocator service provider in India.

Source: Datastream, Goldman Sachs Global Investment Research.

Glossary

Advanced driver assistance system (ADAS): ADAS is a system developed to support, complement, and substitute driver's complex automobile operation process. Its functions include lane departure warning, forward collision warning, and adaptive high beam assist.

Carbon fiber reinforced polymer (CFRP): CFRP is a fiber-reinforced polymer that contains carbon fibers, and is often made with epoxy resin as its base material. CFRP is strong but lower in density and lighter in weight compared to metal materials such as iron and aluminum, and is mainly used in aircrafts and sports goods.

Continuously variable transmission (CVT): CVT is a transmission that can change seamlessly without a gearshift. CVT limits power losses and achieves great fuel efficiency as it can continuously change gear ratios.

Electric vehicle (EV): EV is an automobile that runs on a motor with electric power charged from an external source. It is free of CO2 emissions as it does not use gasoline or other petroleum derivatives. Lithium ion batteries are the mainstream power source for EVs.

Fuel cell vehicle (FCV): Whereas a gasoline car obtains kinetic energy using an engine to heat the gasoline, an FCV stores hydrogen as fuel and generates power using a fuel cell installed in the vehicle. Since electricity is used to power the motor, FCVs have similar properties to electric vehicles (EVs) and are also called FCEVs.

Homogenous charge compression ignition (HCCI) engines: Gasoline engines that work through auto-ignition. HCCI engines may be capable of reducing fuel costs by about 30% compared with current models.

Hybrid vehicle (HV): An HV is an automobile that runs on two power sources: Engine and electric motor(s). HVs largely break down into three categories based on their drivetrain, namely series, parallel, and power-split. The motor's support leads to fuel efficiency improvement during the drive.

Internal combustion engine (ICE): ICE is a collective term used to describe an engine that functions based on heat energy driven from fuel combustion within a cylinder. Currently gasoline and diesel are the mainstream engines.

Lane keeping assistance (LKA): Addition to LDW, the system helps the car stay on course near the center of the lane by continuously applying a small amount of counter-steering force.

Lane departure prevention (LDP): In addition to LDW, LDP activates the brakes automatically to help move your vehicle back into its lane.

Lane departure warning (LDW): It is a driver assistance system alerts the driver with acoustical or haptic warnings before his vehicle is about to leave the lane.

New car assessment program (NCAP): Collision safety test standards set by countries. The Insurance Institute for Highway Safety (IIHS) has considerable influence in the US.

Plug-in hybrid vehicle (PHV): PHV is a type of HV that allows one to charge electricity directly to a storage battery from a residential power plug. Similar to HVs, PHVs have series and parallel drivetrains. A PHV's battery volume is larger compared to that of a HV, but smaller compared to that of an EV. Driving distance for PHVs depends on the battery size.

Usage-based insurance (UBI): UBI is an insurance which payments change based on the driver's travel distance and driving behaviors.

World-Harmonized Light-Duty Vehicles Test Procedure (WLTP): WLTP is a global harmonized standard to test CO2 emissions and fuel consumption, and is currently being developed under the Article 29 Working Party (WP29). The procedure will likely provide results with a more accurate reflection of actual fuel economy relative to unique test procedures currently adopted by each country.

Zero emission vehicle (ZEV) regulations: The emission regulatory framework at the state level in the United States. Regulations announced by California will exclude hybrids from the ZEV category from 2018 and only include PHEVs, EVs, and FCVs.

Disclosure Appendix

Reg AC

We, Kota Yuzawa, Patrick Archambault, CFA, Stefan Burgstaller, Bill Shope, CFA, Heather Bellini, CFA, Heath P. Terry, CFA, Michael Nannizzi, Yipeng Yang, Pramod Kumar, Seung Shin, Taichi Noda and Wataru Matsuzaki, hereby certify that all of the views expressed in this report accurately reflect our personal views about the subject company or companies and its or their securities. We also certify that no part of our compensation was, is or will be, directly or indirectly, related to the specific recommendations or views expressed in this report.

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